INDIA OF TO-DAY

VOLUME VIII

THE DEVELOPMENT OF INDIAN AGRICULTURE

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2288

17 NOV 1930

SECOND EDITION

HUMPHREY MILFORD

OXFORD UNIVERSITY PRESS

LONDON BOMBAY CALCUTTA MADRAS

1929

First edition published January 1928
Second edition published April 1929

2288
COIMBATORE-3

Printed by V. P. Pendherkar, at the Tutorial Press
211a, Girgaum Back Road Bombay
and
Published by Humphrey Milford at the Oxford University Press
B. I. Building, Nicol Road, Bombay

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GENERAL EDITOR'S NOTE

THE opinions expressed in this book are those of the authors. No other person shares responsibility for them.

J. COATMAN

PREFACE TO THE FIRST EDITION

In 1924 we were requested by the Oxford University Press to prepare a short account of the present position of agriculture in India. The completion of this task has been greatly delayed by the work involved in establishing the new Institute of Plant Industry at Indore in Central India.

The results obtained by the Agricultural and Cooperative Departments during the last twenty years have removed two misconceptions which were current at the beginning of this century, namely (1) that science can teach the cultivator nothing and (2) that even if the villager can be helped, he will never alter his present practices. The work of the Experiment Stations and that done among the people have proved beyond all doubt that great progress is possible.

The question to be settled now is the rate of development in the near future. In this matter the country has arrived at the parting of the ways. On the one hand, a great step forward is possible, provided the various independent departments working in the villages can be welded together into a single efficient agency, dealing with rural India as a whole. On the other hand, very modest progress can be achieved with the present means. It is for India to decide by which of these two roads she intends to travel.

A. H.
G. L. C. H.

INDORE
30th April 1927

PREFACE TO THE SECOND EDITION

The publication of a second edition has enabled us to bring this book up to date and to include in the bibliographies at the end of each chapter the chief publications which have appeared during the last twelve months.

A. H.
G. L. C. H.

INDORE
31st August 1928

CHAPTER I

THE POSITION OF AGRICULTURE IN INDIA

Agriculture is and for many years to come must remain India's greatest industry. It provides occupation, directly and indirectly, for the great majority of the people of the country. The census returns of 1921 show that 224,000,000 people or 71 per cent of the total population of 316,000,000 were directly dependent on agriculture. If we add the pastoral and hunting occupations, the percentage rises to 73. In addition, the numerous village communities contain, besides those directly concerned with agriculture, many other members whose livelihood depends on the tillers of the soil and who are therefore supported by the produce of the country-side. Further, a number of others combine agriculture with various urban pursuits. Trade and transport, on which less than six per cent and two per cent respectively depend, are also largely concerned with the produce of the soil. It has been estimated that more than 90 per cent of the people of rural India live directly or indirectly on agriculture. On the other hand, industries—including those of an un-organized character which deal with household and personal necessities and simple implements—support only ten per cent of the population. Organized industries, of which cotton and jute are the most important, occupy only one per cent of the people. The distribution of the population in 1921, according to occupations, is given in Table I.

TABLE I. GENERAL DISTRIBUTION OF POPULATION

Occupational sub-class	Number per 10,000 of total population supported	Percentage of increase or decrease
TOTAL	10,000	
Agriculture, pasture and hunting	7,298	+ 1·8
Industries	1,049	− 6·0
Trade	573	+ 2·0
Professions	159	− 7·1
Domestic service	144	− 0·6
Transport	137	−13·8
Administration	84	− 1·0
Police, Army and Navy	69	− 9·0
Mines and minerals	17	+ 2·3
Independent incomes	15	−11·1
Unclassified	351	+20·1
Unproductive	104	+ 5·7

The millions of rural India for the most part live as primitive village communities and cultivate small holdings, often less than five acres in area—the exact size varying with such factors as soil, climatic conditions, pressure of population and irrigation facilities. In the *Census Report* of 1921, the relation between the number of workers and the acreage cultivated has been calculated for the chief provinces of British India. The figures are given in Table II. They illustrate how intense is the struggle for existence in India.

TABLE II. THE RELATION BETWEEN MAN POWER AND CULTIVATED AREA

Province	Number of acres cultivated per 100 ordinary cultivators
Bombay	1,215
North-West Frontier Province	1,122
Punjab...	918
Central Provinces	848
Burma	565
Madras...	491
Bengal	312
Bihar and Orissa	309
Assam	296
United Provinces	251

These minute holdings are frequently cultivated by extensive methods (those suitable for large areas) which neither utilize the full energies of the workers nor the potential fertility of the soil. Such a system of agriculture is bound to prove un-economic and to result in poverty.

By far the most important feature of this peasant agriculture is crop-production. The crops grown fall into two classes—(1) food and fodder crops and (2) money crops. The former includes, in order of area, rice, millets, wheat, pulses and fodder crops, barley and maize, and sugar-cane. The money crops are more varied; cotton and oil seeds are the most important, followed by jute and other fibres, tobacco, tea, opium, indigo and coffee. In Table III, a general summary is given of the agricultural statistics of British India for 1926-27. It will be seen that food and fodder crops comprise eighty-two per cent of the total area under crops and that money crops, as far as extent is concerned, are relatively unimportant.

TABLE III. AGRICULTURAL STATISTICS OF BRITISH INDIA, 1926-27

Area, in acres, under food and fodder crops		Area, in acres, under money crops	
Rice ...	78,502,000	Cotton ...	15,687,000
Millets ...	38,776,000	Oil seeds, chiefly rape and mustard, sesamum, groundnuts and linseed	14,999,000
Wheat ...	24,181,000		
Gram ...	14,664,000	Jute and other fibres ...	4,411,000
Pulses and other food grains ...	29,154,000	Dyes, tanning materials, drugs, narcotics and miscellaneous money crops ...	1,729,000
Fodder crops ...	8,940,000		
Condiments, spices, fruits, vegetables and miscellaneous food crops ...	7,537,000	Tobacco ...	1,055,000
		Tea	738,000
Barley ...	6,387,000	Opium	59,000
Maize ...	5,555,000	Indigo	104,000
Sugar ...	3,041,000	Coffee ...	91,000
TOTAL food and fodder crops ...	216,737,000	TOTAL money crops ...	38,873,000

The primary function of Indian agriculture is to supply the cultivator and his cattle with food. Compared with

this duty all other matters are subsidiary. The houses are built of mud, thatched with grass and are almost devoid of furniture. Expenditure on clothing and warmth is, on account of the customs of the country and the nature of the climate, much smaller than in European countries. Nevertheless, the cultivators require a little money with which to pay the land revenue and to purchase a few necessaries in the village markets. Hence the growth of money crops to the extent of about one-fifth the total cultivated area. The produce, after conversion into cash, is afterwards either worked up in the local mills or exported. To some extent food crops are also money crops. The population of the towns and cities is largely fed from the produce of the soil while in addition a small percentage of the total food grains produced is exported to foreign countries. In some crops like sugar-cane, the total out-turn is insufficient for the towns and large quantities of sugar are imported from Java, Mauritius and the continent of Europe. The yields of the more important crops are given in Table IV.

TABLE IV. YIELD OF THE MORE IMPORTANT CROPS, 1926–27

Food crops			Money crops		
Rice	29,636,000	tons	Jute ...	12,132,000	bales
Wheat	8,941,000	,,	Cotton ...	4,960,000	bales (each 400lb.)
			Ground-nuts	2,035,000	tons
Millets	7,806,000	,,	Rape and mustard ...	986,000	,,
Gram	3,979,000	,,	Linseed ...	407,000	,,
			Sesamum ...	411,000	,,
Barley	2,550,000	,,	Castor seed...	128,000	,,
			Tea ...	392,917,800	lb
Sugar	3,234,000	,,	Coffee ...	34,286,806	,,
			Rubber ...	23,002,700	,,
Maize	1,919,000	,,	Indigo ...	18,100	cwt.

Animal husbandry is much less important than crop-production in all but a few thinly populated areas where the soil and rainfall ensure ample supplies of grass. In such tracts, such as the upland areas of Central India, North Gujerat, Nellore, Kheri, South Kathiawar, Mysore and parts of the Punjab and Sind, the best breeds of work cattle are raised and exported to the more densely populated areas. A few find their way overseas. The milk supply of the country is derived almost entirely from the buffalo, a species which possesses high digestive powers and is able to maintain itself and also produce large quantities of milk on a diet on which the best strains of European dairy cattle would starve. The finest breeds of buffalo are the Delhi (North-West India) and the Jafarabadi (Kathiawar). Good cows of these breeds yield from 40 to 50 lb. of milk per day and command high prices. Cattle and buffaloes are raised entirely for work and milk. There is no export of meat or dairy products. Hides (raw and tanned), however, are an important item of the foreign trade and mostly find their way to Europe and the United States. Besides cattle and buffaloes, the country raises for internal use flocks of sheep and goats of a nondescript character, as well as a number of horses, donkeys and camels. A small amount of wool is exported.

Before the opening of the Suez Canal in 1869 and the great development in communications of the last fifty years took place the Indian village community, except in times of famine, supported itself. The volume of produce exported was then small. The construction of roads and railways, coupled with the growth of shipping facilities at the ports, has rapidly brought the cultivator within the influence of the world's markets. These factors are converting him into a specialist. He has begun to grow such crops as cotton, jute, wheat and oil-seeds for sale and to purchase his food supplies. In other words, he is *beginning to live on the profits derived* from his holding rather than, as heretofore, on its products. Great developments in this direction have taken place in the last twenty years in the cotton-growing areas on account of the high price of cotton. The

TABLE V. PRINCIPAL ARTICLES OF EXPORT ARRANGED IN ORDER OF THEIR IMPORTANCE, 1925–26

Exports	Value in thousands of rupees
Cotton, raw and manufactured	1,04,64,13
Jute " "	96,78,56
Food grains	48,03,39
Oil-seeds	29,63,68
Tea	27,12,17
Hides, skins and leather	14,33,59
Metals and ores	7,28,83
Lac	6,90,10
Wool, raw and manufactured	4,59,48
Rubber	2,94,10
Oil-cake	2,10,62
Timber	1,95,74
Opium	1,93,37
Coffee	1,85,26
Oils (essential, mineral and vegetable) ...	1,79,29
Spices	1,76,28
Paraffin wax	1,59,45
Hemp	1,59,17
Dyes and tanning substances	1,33,11
Fodder and bran	1,28,58
Manures	1,17,49
Tobacco	1,11,40
Coir	1,08,27
Mica	1,04,17
Fruits and vegetables	83,46
Fish	76,44
Provisions and oilman's stores	63,79
Silk	38,76
Miscellaneous	7,31,55
TOTAL VALUE OF EXPORTS ...	373,83,23

cultivators of tracts like Berar grow cotton at the expense of food-stuffs and in consequence have to be fed from other parts of India. The recent fall in the price of the raw material, by restricting production, will no doubt tend to the increased cultivation of local food crops and to the substitution of other money crops, such as ground-nuts, for cotton. The area under ground-nuts, which is largely grown for export, has also increased of late years.

The importance of agriculture to the welfare of India is perhaps most clearly recognized when the list of articles exported (see Table V on page 7) is carefully examined. The chief items in the export trade, on which the prosperity of the country is founded, are, in order of value, cotton and jute (raw and manufactured), food grains, oil-seeds, tea, hides, skins and leather. These comprise no less than 85 per cent of the total value of the export trade. A long list of miscellaneous products make up the exports of agricultural origin to nearly 95 per cent. Raw agricultural products amount to no less than 72 per cent of the total exports. Non-agricultural exports comprise less than six per cent of the export trado of the country.

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CHAPTER II

THE FACTORS UNDERLYING PRODUCTION

The first step in the development of rural India is a careful study of the present agricultural conditions of the country. The factors involved, both agricultural and human, must be recognized and defined. Fortunately, a great deal has already been accomplished in this direction and it is now possible to bring together a vast mass of scattered work and to consider the main features of rural India as one subject.

THE AGRICULTURAL FACTORS

It is not possible, in the space available, to describe in detail the various agricultural practices which occur in a country the size of India. An attempt, however, will be made to record the main factors underlying Indian agriculture, which have been closely studied during the last twenty years.

The place of the crop in Indian agriculture. The outstanding feature of Indian agriculture is the importance of the plant. The country is a land of small-holders chiefly occupied in the raising of crops. Not only the population but also the trade of the country depend on the produce of these millions of small fields. To increase the well-being of India, therefore, crop-production must be stimulated and each unit must be made to yield either more produce, more valuable produce, or an increased yield of a better quality than the average. To accomplish this two things are necessary: a knowledge of plants and how they work and the discovery and application of practical methods of speeding up growth.

The essential nature of a crop can be stated in a few words. It is a group of living factories which makes use of two classes of raw material: one obtained from the soil, the other from the atmosphere. Various mineral salts, in dilute solution in water, enter the plant from the soil by way of the root-system and are carried to the green leaves by the upward transpiration current. From the atmosphere, oxygen and carbon dioxide reach the same point by way of the pores of the leaf. In the green cells, these two classes of raw materials are worked up into complex food substances by means of energy focussed from the sun through the medium of the chlorophyll corpuscles. Unlike an animal, a plant has to make its own food before it can feed. In both cases the actual food, however, is very similar. The crop has to manufacture food, to develop new organs and to complete its life cycle under constantly varying conditions as regards the supply of raw materials, temperature, illumination and humidity. The manufacture of its own food by the green leaves is the first work of the plant. Its second duty is to provide a surplus—in the shape of reserve materials which are often packed into the seed—for the use of the next generation. Man intercepts these reserve materials for his own use, and on their amount and quality the success or failure of crop-production depends. In this manufacture of food, it is well to bear in mind the fact that the plant has always to feed itself first of all and that the formation of reserves marks as it were a second stage of activity. Naturally the higher the efficiency of the factory the more food there will be for growth and the greater will be the volume of the reserves. The duty of the investigator of crop-problems is to study the working and out-put of this natural factory, to discover the directions in which it can be improved and then to devise the most practical method of carrying this out in the field.

The monsoon and agriculture. An adequate supply of soil water for the plant is the first condition of success in crop-production. Without this the plant cannot make full use of the natural fertility of the land. Hence the dependence of the crops of India on the monsoon and the

importance of a well-distributed rainfall to the country. The monsoon is the dominant factor in rural India. Its immense importance to the country-side can only be fully realized after a sojourn of many years. To the cold-weather visitor, the rains must at the most remain a name. An experience of a single rainy season is only the first step in the education of the student of rural India. After twenty years or so, a realization of the full significance of the monsoon becomes possible. In that time words are translated into first-hand experience. The well-known uncertainty of the monsoon produces other effects besides limiting the annual harvest. The character and outlook of the population have been affected. The people feel that the monsoon is in command. The villager is convinced that he has to accept what providence has seen fit to provide. Hence the well-marked fatalism of the people, the general stagnation of village life and the absence of any desire on the part of the cultivator to improve his condition. Anything approaching a high morale cannot therefore be expected under such conditions. It is not surprising to find that it does not exist.

Considerable progress has been made in removing the worst consequences of an irregular rainfall. The surplus water running to waste in the great rivers, notably in those of the Indo-Gangetic plain, has been led to the fields of the cultivators by a network of perennial and inundation canals. In peninsular India, some of the excess rainfall is stored on the surface in large reservoirs. All over the country the large supplies of subterranean water are tapped by means of wells and raised to the surface chiefly by cattle power. Besides these direct methods of supplementing the rainfall, a little has been done by indirect means in the shape of embankments by which the run-off on sloping land has been checked and either given time to percolate into the soil or to be retained so that rice, a semi-aquatic crop, can be cultivated. Imposing as these various efforts in supplementing a precarious rainfall at first sight appear, a little consideration forces one to the conclusion that little more than the fringe of the subject has been touched and that

only a beginning has been made in the regulation of the rainfall for the benefit of crops after it has reached the surface of the country.

The Indian monsoon has produced two other results besides influencing the outlook of the people and often reducing the supply of moisture for the crops. In the first place the heavy falls of rain, which often occur, lead to constant erosion and to the loss of the most fertile portion of the soil. In the second place the duration of the monsoon is so short that only rapidly-maturing varieties of low potential yield can be cultivated.

The annual loss of soil which takes place in India by erosion is immense and is an important factor in reducing the annual harvest. Except in the rice areas, soil-erosion takes place all over the country and is particularly harmful on the upland areas of peninsular India. In these tracts, the scientific control of surface drainage does not yet exist. Much of the rain is received in heavy falls; a large portion of the water runs off the surface towards the drainage lines, carrying with it the most valuable portion of the soil—the fine particles and a large part of the organic matter. Sometimes this drainage from the higher land leads to the water-logging of lower areas before it reaches the rivers. In other cases the surplus water runs to waste so rapidly that there is no time for it to soak into the soil. The crops then suffer and the reserve of water in the sub-soil is not replenished. All these adverse factors—soil-erosion, water-logging and a shortage of soil moisture—occur because there is no control of the rain after it reaches the ground. It is only in years when the rainfall is well distributed that no harm is suffered. When the showers are light and frequent, there is ample time for absorption without water-logging, while at the same time the loss of fertile silt by erosion is negligible. In such seasons bumper crops are obtained even when the total rainfall is below the normal.

Examples of the evil consequences which result from the want of control of the surface-drainage are unfortunately only too abundant. Thousands of acres of valuable land on the left bank of the Jumna have been destroyed

by the formation of a network of ravines which produces little more than a crop of grass in the rains. These gullies have been carved out of the soft alluvial soil by the uncontrolled drainage in the past. Every year they extend further and further from the river, until, at the present time, they measure many hundreds of yards in length. Villages, which at one time were surrounded by fertile fields, now lie in a network of useless ravines. It is true that successful experiments in the afforestation of this strip of desert land are being undertaken by the Forestry Department and that in time a supply of useful timber and better fodder will result, but the area devasted is far too large to be rapidly reclaimed in this way. Further the expense is considerable. The real remedy for such damage is prevention—the control of the drainage in the first instance. In matters such as this, little can be hoped from individual cultivators, as they are too intent on their small areas of land besides being too poor and too ignorant to execute a drainage scheme for the country-side.

Less striking than the ravine lands of the Jumna, but far more extensive and therefore more important, is the erosion which goes on on the soils of the peninsula—in Central India, Gwalior, the Central Provinces and Bombay. Some eighty years ago, Sleeman drew pointed attention to the damage done by uncontrolled drainage in these areas in the following words: "I am disposed to think that the most productive parts of the surface of Bundelkhand, like that of some of the districts of the Nerbudda territories which repose upon the back of the sandstone of the Vindhya chain, are fast flowing off to the sea through the great rivers, which seem by degrees to extend the channels of their tributary stream into every man's field, to drain away its substance by degrees, for the benefit of those who may in some future age occupy the islands of their delta. I have often seen a valuable estate reduced in value to almost nothing in a few years by some new *antennae*, if I may so call them, thrown out from the tributary streams of the great rivers into their richest and deepest soils. Declivities are formed, the soil gets nothing from the cultivator but the mechanical aid of the plough, and the more its surface is ploughed

and cross-ploughed, the more of its substance is washed away towards the Bay of Bengal in the Ganges, or the Gulf of Cambay in the Nerbudda. In the districts of the Nerbudda, we often see these black hornblende mortars, in which sugar-canes were once pressed by a happy peasantry, now standing upon a bare and barren surface of sandstone rock, twenty feet above the present surface of the culturable lands of the country." Sleeman's remarks are true to-day except in those cases where enlightened administration has encouraged and assisted the people to check this denudation by means of embankments. Nothing strikes the traveller, during the rains in the black soil areas of the peninsula, more than the universal scouring of the fields by the run-off and the enormous annual loss of the best portion of the soil. If only the surface-drainage were controlled, this loss of fertile soil would stop and time would be given for the water to soak into the soil. This increased absorption would check erosion and would lead to better crops. It would also raise the spring-level and thus maintain the wells in action during the cold season and the succeeding hot weather. In some areas the soil of whole valleys has been removed by denudation and the rocky sub-soil left only maintains with difficulty a thin covering of scrub. Soil-formation, however, is going on even in such tracts, and it is extraordinary how quickly fertile land can be re-created by means of properly constructed embankments stretching across the valley. In the Gwalior State, examples of such reclamation are numerous, and fine stretches of wheat are now being grown on the soil held by these embankments. In Bombay, many other examples of the successful control of rain-water, after it has fallen, exist. These not only indicate the remedy for a state of things which leads to a great annual drain of the natural capital of India, but also prove how rapid is the decay of the rocks and how much new soil is being created every year. Although erosion is extensive, it is partly counterbalanced by the formation of fresh soil. The position, therefore, is not hopeless provided denudation can be stopped and the yearly accretions of new earth can be collected and retained.

It is in the planting areas of the east, however, that the most striking examples of soil denudation are to be found. Instances of damage to the natural capital of the country are to be seen on the tea estates near Darjeeling, in the Kumaon hills, on the plantations in Ceylon and Assam, and in the planting districts of southern India and the Federated Malay States. In most of these areas forest land was so abundant that the need for the preservation of the soil was not at first recognized. Thanks to the efforts of Hope, a former scientific officer employed by the tea industry in Assam, the control of the drainage and the checking of erosion are now widely recognized and are being dealt with by the planters in many parts of India. A great impetus to this work was given by the publication in India of a detailed account of the methods in use by the Dutch planters in Java, where the terracing and drainage of sloping land under tea and other crops has been carried to a high state of perfection. In this island, the area of land available for planting is strictly limited, while the feeding of the large indigenous population is always a serious problem. As a consequence the development of the island is very strictly controlled by the Government, and one of the conditions of planting new forest lands is the provision of a suitable system of terraces, combined with surface-drainage. The advantage is not all on the side of the state. The manuring of tea soils in Java is far less necessary than in Ceylon and India, while one important consequence of the retention of the valuable soil made by the forest is healthy growth which suffers remarkably little damage from insect and fungoid pests.

Soils. The majority of the cultivated soils of India are well above the average in fertility. Particularly is this the case if due weight is given to the heavy cropping to which they are subjected and to the small quantity of manure that is applied. Their chief defect is the low content of organic matter. Given a supply of this material in a suitable condition for rapid nitrification, the response both in the rate of growth and in the total yield is marvellous. In almost every part of India myriads of examples of this basic fact are to be observed.

The highly manured lands round the villages yield crops luxuriant in comparison with those of the outlying unmanured fields. The whole country-side is a gigantic manurial experiment and the certain results which follow the addition of organic matter to the soil need no investigation. As most of the cow-dung is burnt, other sources of organic matter must be exploited. The problem is to show the people how to make the most of the organic matter now available and how to improve the supply.

After the increase in the content of organic matter and the provision of an adequate supply of moisture there is another soil factor, namely the supply of oxygen, which often needs attention. This is required for the soil organisms and the roots of the growing crop and is a factor of paramount importance in a country where the growth period is short and where the soils are often finely divided. If the air-supply of the soil is in defect, serious trouble ensues. The preparation of food materials for the plant becomes impossible and the crop is unable to develop an adequate root-system. Valuable time is lost and the yield suffers, although everything else—potential soil fertility, ample soil moisture and a suitable variety—may all be present together. An inadequate supply of oxygen in the soil puts a brake on the wheel of life.

In many of the alluvial soils of north-west India, including Sind, the shortage of oxygen in the soil becomes so great that a condition of extreme oxygen hunger is set up. A change in the soil flora takes place : a group of soil organisms, which are able to extract the oxygen they need from various salts in the soil, is established. The new soil population sets up a condition of intense reduction which eventually leads to the development of the alkali condition—a phase which marks the death of the soil as far as crop-production is concerned. The amount of soluble sodium salts in land in this condition renders the soil solution too concentrated for the growth of crops. The roots cannot absorb moisture and the crop withers. This alkali condition is very common in parts of the United Provinces, the

Punjab and Sind and is everywhere associated with soils through which water can only pass with great slowness or not at all. When water cannot pass readily through a soil, adequate aeration is out of the question and the subsequent development of the alkali condition is only a question of time. This danger is greatest when close, stiff, alluvial soils are brought under perennial irrigation. The constant flooding of the surface causes the soil particles to settle into a condition of close packing and to produce gummy substances known as colloids. The supply of air then becomes restricted and there is a rapid fall in productivity. The alkali condition follows. The soil dies. The land goes out of cultivation.

The varieties cultivated. The restricted supply of soil moisture and the short period of growth make it impossible to cultivate high yielding types. The concentration of the monsoon rainfall into a period of between three and four months limits the growth-period of the crops cultivated. Only rapidly maturing varieties can be grown in the rains. Such varieties must of necessity be low yielders. In the cold season, when crops are raised either on irrigation or on the moisture stored in the sub-soil, the temperature factor limits the growth-period and the choice is again restricted to rapidly maturing types. Both monsoon and cold weather crops therefore have one feature in common—early maturity and low potential yielding power. With few exceptions,[1] the characteristic of all Indian crops is a short growth period, a fact to which sufficient weight is rarely given when the low average yields of this country are compared with those of more favoured localities. This general characteristic limits the degree of improvement. The full potentialities of plant-breeding can therefore never be realized in India.

Besides early maturity, the crops grown have a number of other characters in common. Admixture of

[1] In the Punjab and North-West Frontier Provinces, the cold weather crops have a longer season and here yields above the Indian average are possible.

varieties is the rule. There is nothing approaching uniformity in the sample and the quality of the produce is often low. Only the first steps in the establishment of grades, comparable with those which are now the rule in the produce shipped from America, have been accomplished in India. Sales take place for the most part only after the product has been examined. Adulteration with foreign seeds, water or earth is a constant complaint. There is no organization of the seed supply, seedsmen do not exist and no indigenous methods of improving the variety were in existence when this matter was taken in hand by the Agricultural Department some twenty years ago.

Animal husbandry. Oxen furnish most of the power needed for cultivation and transport in India. In the rice areas, buffaloes are employed for ploughing. In Rajputana, the camel to some extent replaces the ox. Buffaloes, cows and goats provide milk. A remarkable feature of the supply of cattle is the vast number of old and worn out animals. As the cow is a sacred animal and the people are mostly vegetarians, it is not possible to use these animals for food. Keatinge states that, in the Bombay Deccan alone, the number of useless animals is no less than 900,000. These have to be fed. A severe drain is in this way imposed on the slender fodder resources of the country. Epidemics of disease and the acute shortage of fodder which follow a failure of the rains are the only factors which operate in keeping the bovine population within bounds. Except in the rice areas, the work cattle of India, when properly fed and tended, are fine animals, seldom sick or sorry and remarkably hardy and resistant to disease. There is little or nothing wrong with the breeds of cattle. What is needed is an ample food supply, particularly in the early years, and the provision of local fodder reserves to meet the periodical shortages which occur. The preparation of silage is almost unknown among the people and the amount of reserve straw and dried grass held over from good years is exceedingly small. In the rice, jute and cotton areas, the pressure of these crops on the cultivated area is so great that the work cattle have

to be imported and little provision is made in the shape of fodder crops to maintain the animals in a high state of efficiency. Casualties are frequent and the supply has to be maintained by constant importation from other tracts.

Communications. Communications in agricultural India are good as far as railways are concerned and every year they are improving. The provision of inexpensive types of road railways and feeder lines as well as the bridging of rivers and the condition of the country roads leave a good deal to be desired. This work has been greatly interfered with by the war of 1914–18 and by the period of financial stringency which followed it. Some improvement is now taking place but a great deal remains to be done to bring the fields of the cultivator into better touch with the markets of the world. For the conveyance of the population in rural areas, the motor omnibus already supplements the railway but this form of transport is still too expensive for produce like un-ginned cotton and seeds. These are still moved by oxen in the primitive country cart.

THE HUMAN FACTOR

"In the end it is the character of the cultivator that counts."—*Calvert.*

Since the co-operative movement began some twenty years ago, the human factor has received more and more attention in India and during the last few years a number of valuable studies, dealing with rural economy, have been carried out, notably in the Punjab and Bombay.

The chief factor in production, in any country, must always be the cultivator himself. As a writer on Ireland truly remarks: "The wealth of a nation lies, not in the material resources at its command, but in the energy, initiative and moral fibre of its people; without these attributes no country can become permanently prosperous; with them, no unfavourable circumstance can long prove an insuperable obstacle." While the importance of the man behind the plough can hardly be exaggerated, nevertheless, this is by no means the

whole question. Much can also be done to achieve progress by education, by intelligent direction and by prolonged effort even under conditions the reverse of favourable.

In Europe, Denmark offers an example of the *successful transformation* of rural life in little more than a generation. The fertility of the land has been raised, a successful dairy and bacon industry has been established, its products have been standardized and command high prices in foreign markets. The educational system of the country districts (founded on the pioneering work of Grundtvig) stands at a high level and provides a constant supply of efficient human material for the improvement of the soil. The calamities which followed the war of 1868 gave birth to an intense desire to develop agriculture, the results of which are to be seen to-day. This material progress has taken place almost within the memory of men now living. "In the early nineteenth century the Danish peasant was still unprogressive, sullen and suspicious; averse from experiment, incapable of associated enterprise. To-day he is forward-looking, cheerful, scientifically minded, resourceful, co-operative."—*Sadler.*

In India itself large areas of desert land in the Punjab which a generation ago maintained a few troublesome nomads and their herds, have now, thanks to the development of canal irrigation, been converted into fertile fields. By ensuring a supply of water and by providing transport facilities for bringing the fields of the cultivator in touch with the world's markets the desert has been transformed.

In the agricultural developments which have taken place in Denmark and in the Punjab the natural character of the people has no doubt counted for much. By itself however, it could never have brought about the results we see to-day. In Denmark, the chief factors were two—adversity and an efficient system of rural education. In the Punjab, the canal colonies are mainly the result of settled government, of enlightened administration and of the existence of congested districts in the eastern part of the province.

Although India, in the success of the canal colonies, affords one striking example of successful agricultural development, nevertheless much remains to be done in the re-creation of the rural population as a whole. The village communities are everywhere uneducated and unprogressive, and no desire for better amenities in the shape of improved communications, efficient schools, dispensaries and better markets has disclosed itself. Still less has any rural movement arisen for raising the money to pay for these improvements. Although the Reforms have been in operation for some years, the newspapers contain no accounts of public meetings in rural areas called for the purpose of impressing on the elected representatives of the people what agricultural India desires. Even the urban areas have only reached the stage of formulating demands for official assistance. The necessary note of pressing for improvements to the point of sacrifice is still a matter for the future. The fact must, therefore, be faced that in the development of rural India not only its soil, crops and cattle but also its people must be considered. The first step is to study the village community. This is now being done and a good many results are available. These can be summed up in a few words. The people of rural India are for the most part uneducated, illiterate and almost incapable of thinking for themselves. The majority are born in debt, live in debt and die in debt. Even in the modern villages of the canal colonies, money-lending has become one of India's greatest industries. Elsewhere, the holdings are for the most part small and are frequently fragmented into a number of scattered fields, difficult to cultivate and impossible to improve. Even the best cultivators have little or no capital for developing their fields. Everywhere agricultural land is regarded as a convenient means of investing money so that the rents can provide a certain income. Only in rare cases is money devoted to land improvement. In many parts of the country the pressure of population,[1] both human and bovine, is intense and

[1] In fifty years (1872-1921) the population of British India increased by sixty-two millions, i. e., by 20 per cent.

but for the high infant mortality and periodical waves of pestilence the position would become desperate. Clearly the first step in progress is to educate the people—the adults by such means as the co-operative movement and the force of example; the children in suitable schools.

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CHAPTER III

THE ORGANIZATION OF AGRICULTURAL RESEARCH

The first organized effort to improve Indian agriculture was that initiated by the late Lord Curzon in 1904. Up to that time, a number of attempts to form Agricultural Departments had been made by the East India Company, the Government of India and the provincial Governments, but none of these projects took firm root. Although these earlier experiments failed, nevertheless two important pieces of work were accomplished. In 1887, the results of Sir George Watt's patient work on the crops of India were made available in his well-known *Dictionary of Economic Products.* This was followed in 1893 by Dr. Voelcker's interesting *Report on the Improvement of Indian Agriculture.*

In 1904, Lord Curzon sanctioned the formation of an Imperial Agricultural Research Institute at Pusa under the direction of Mr. Bernard Coventry. The new institute was erected on a disused government estate of 1,358 acres and a sum of twenty lakhs of rupees (£133,000), including a donation of £30,000 from the late Mr. Henry Phipps, was devoted to the undertaking. At that time the Imperial Department of Agriculture consisted of an Inspector-General of Agriculture, an Agricultural Chemist, a Cryptogamic Botanist and an Entomologist, all of whose duties were largely advisory. None of these officers were provided with land for experimental purposes. Two were stationed at Dehra Dun, while the Inspector-General of Agriculture had his head-quarters at Nagpur. After the decision to found the Pusa Research Institute, the existing staff of the Department was concentrated there and three additional officers were appointed to deal with the following sub-divisions of the subject—Agriculture, Bacteriology and Economic Botany.

In March 1905, the Government of India decided to set aside a sum of twenty-four lakhs of rupees for the development of separate Agricultural Departments in each of the larger provinces. From that date the organization of agricultural work in India has followed the two main divisions—Imperial and Provincial—in the administration of the country. In the new scheme, each important province was to have an Agricultural College and a Research Institute of its own, and the number of experimental farms was to be considerably increased. Plans for new Agricultural Colleges and Research Institutes at Cawnpore, Lyallpur, Poona, Nagpur, Coimbatore and Sabour were prepared and steps were taken to recruit for each province a scientific staff on the lines of that already in residence at Pusa. Simultaneously, the organization of the work to be carried on in the Districts was taken in hand. The ideal kept in view from the beginning was an experimental farm for each important distinct agricultural tract. The chief provinces were divided into Circles, the experimental farms of which were placed in charge of an expert agriculturist (the Deputy Director of Agriculture) trained in general agricultural science and practical farming. The head-quarters of the Deputy Director were placed at his most important experimental farm. His duties consisted in the supervision of all the agricultural work in the circle including the experiment stations, demonstration plots, the testing and distribution of seeds, implements and special manures. He was, in short, expected to be the guiding spirit in all matters relating to agriculture in his circle. The duties of the scientific members of the Provincial Agricultural Departments were laid down in an official memorandum on the subject, published by the Inspector-General of Agriculture (*Agr. Jour. of India*, I, 1906, p. 1) in the following words:—"The specialists will be located at the Provincial Research Institute, and will not only conduct research work in their laboratories and their headquarters experimental farm, but will tour throughout the Province, visiting all experiment stations, guiding the work connected with their special branch and inquiring into the local conditions

of all tracts. The Agricultural Chemist will investigate all chemico-agricultural matters. The region in which the Agricultural Chemist will employ himself includes not only the chemical analysis of agricultural materials (such as soils, waters, manures, feeding stuffs, crop products and the like), but also the investigation of special problems. Amongst the problems ripe for investigation may be mentioned the exhaustion of the soil by the present modes of cultivation ; the amount of nitrogen in the rainfall and the loss of soil constituents by drainage; the nature, origin and removal of saline efflorescences; the use of indigenous material for artificial fertilizers ; the sugar-content of different varieties of sugar-cane and the causes affecting it; the date and palmyra palm sugars ; the system of tobacco curing; sewage from an agricultural standpoint. The duties of the Economic Botanist include an investigation of the economic uses of agricultural plants ; a botanical study of the field and garden crops ; the testing of varieties; the transfer of useful varieties from tract to tract; the production of new and improved varieties by selection and cross-fertilization ; the testing of likely exotic plants. The Mycologist will study fungus life in the soil in its relation to plant food, and all fungus diseases of plants, amongst which may be mentioned wheat rust, linseed rust, potato blight, the pepper vine diseases, red-rot in sugar-cane, the wilt disease of the pigeon pea, rusts of millets, smuts of cereals, paddy diseases, the opium poppy blight, diseases of ginger, turmeric and egg plants, all of which cause great losses to the cultivator. The Entomologist will investigate the great number of insect pests injuring the crops and the means of introducing into general use practical remedies. For the present it will be necessary to fill most of these appointments with specialists recruited from Europe and elsewhere, but later on it is hoped that the Pusa College will provide suitable candidates from its best students." It will be seen that the organization of research was based on the separate science and that the problems of Indian Agriculture were to be approached by a number of specialists working independently at a Research Institute.

In order to co-ordinate the work of the Imperial and Provincial Departments the Board of Agriculture, consisting of the staff of the Agricultural Departments, was set up in 1905. At first this board met annually and for a number of years accomplished a large volume of useful work. As was inevitable in a new undertaking of this character, the discussion of programmes of research and the method of approach best suited to the larger problems of Indian agriculture occupied a good deal of space in the earlier proceedings. This continued till 1916, when it was generally felt that with the growing experience of the workers the submission and discussion of programmes no longer served any useful purpose. To prevent overlapping, the general relations between the investigators at Pusa and in the provinces were defined, the scope of the former being restricted to investigations involving the application of each science to the broad general problems of Indian agriculture. In 1908 and subsequent years, interesting discussions took place on the best methods of bringing improvements to the notice of the cultivator. In 1911, important decisions were reached on the need of closer relations between the two independent departments dealing with Co-operation and Agriculture. At the same meeting, agreement was reached on the principles underlying the distribution of improved seed to cultivators.

The rapid expansion of the provincial Departments of Agriculture was followed by a change in the administration. The work on Land Records—which includes the collection and examination of annual statistics of the important agricultural and economic facts of each village, district and province—was separated from Agriculture and two departments were created, each under a civilian director. From the beginning, the co-operative movement has always been kept separate from the work entailed in the improvement of agriculture proper.

Up to the present time, the organization of agricultural research in India by the state has proceeded on the lines laid down in 1906. A number of additions to the structure have been made but no alterations in the

principles of organization have taken place. As a result of retrenchment in 1914, the research work on the diseases of farm animals, carried out by the Government of India at Muktesar and Bareilly, came directly under the Agricultural Adviser to the Government of India. Shortly afterwards, a change in the reverse direction was carried out in the provinces. Veterinary work was controlled by the Director of Agriculture till 1919 when it was separated from Agriculture and placed in charge of a Veterinary Adviser to Government. In 1913 the Imperial Department of Agriculture subsidized a cane-breeding station at Coimbatore in Madras and later on created a Sugar Bureau with headquarters at Pusa. In 1916 the post of Imperial Dairy Expert was created with headquarters at Bangalore where a second bureau—the Bureau of Animal Husbandry—is now being organized. In 1923 the Physiological Chemist was moved from Pusa to Bangalore. In 1919, the post of Imperial Cotton Specialist was abolished. In the provinces, the chief developments in recent years have taken place in the investigations on crops. It was found impossible for the Economic Botanists to teach in the Agricultural College and also to carry out research work on crops. These posts have been duplicated and in some cases crop specialists for cotton, fibres, rice and millets have been appointed in addition to the ordinary cadre. Additions to the original staff have also been made for agricultural engineering and (in the Punjab and Sind) for research into irrigation problems.

The development of agricultural research since 1904 gave birth to a number of other schemes dealing with the same subject. Among official developments outside the Agricultural Department, the recent extension of the cultivation of *Cinchona* and the manufacture of quinine near Darjeeling, in Madras and Burma, may be mentioned. The work on the growth and manufacture of tea, started many years ago and at first subsidized by the central government, has developed into a large research department with its headquarters at Toclai in Assam and with its own publication. These investigations are now entirely supported by the Indian Tea Association. An

experiment station devoted to the problems of the lac industry, and financed by a special lac cess, is now in operation at Ranchi. Near Allahabad, an Agricultural Institute, dealing chiefly with dairy problems, has been founded by Dr. Sam Higginbottom with the help of funds raised mostly in the United States.

A recent departure in the conduct of research work has just taken place. All matters relating to the production, improvement, trade and utilization of cotton are now dealt with by the Indian Central Cotton Committee, an unofficial organization which may be described as a republic of cotton. At first an advisory body, this committee is now incorporated with funds of its own derived from a small tax of two annas a bale (400 lb.) on all cotton used in the Indian mills and exported from the country. The committee consists of about forty members representing the cotton growers, the cotton trade and the research workers engaged on this crop. The co-operative movement has a special representative of its own. Thanks to the invaluable services rendered by the merchant princes of Bombay and of other parts of India, the Indian Central Cotton Committee in the few years of its existence has accomplished a large amount of work and has served to demonstrate the great value of an unofficial association of this character both for the regulation of the trade itself and also for the efficient conduct of research. On the commercial side, the committee has put forward concrete proposals for dealing with the mixing and adulteration of raw cotton. These have been adopted by the Government of India and have become law in the shape of two Acts of the Legislature— one relating to the transport of cotton, the other to the marking of cotton bales. These measures will enable the trade gradually to remove the existing abuses and will pave the way to the ultimate establishment of definite grades of Indian cotton in the markets of the world. On the research side, the committee has established a Research Institute and Testing House at Matunga (Bombay) for the investigation of questions relating to the cotton fibre and for the trial, under standard conditions, of new types of cotton produced by agricultural

workers in India. The committee has also furnished the capital cost and a large portion of the recurring expenditure of the new Institute of Plant Industry at Indore, where particular attention is being paid to the problems connected with the production and improvement of raw cotton. The foundation of this Institute marks a definite departure from the existing organization of agricultural work in India. In place of the conventional approach by way of the separate science, the plant will be regarded as the centre of the subject. A knowledge of several sciences, of practical agriculture and of the requirements of the trade will be brought to bear simultaneously on the chief problems presented by cotton and other related crops. Grants are also made by the Cotton Committee towards the cost of a number of important investigations in the provinces and for the training of post-graduate students. Besides these activities, the committee is undertaking a systematic examination, province by province, of the marketing and finance of the cotton crop, the earlier results of which have recently been published.

Besides the formation of the Indian Central Cotton Committee another unofficial organization has grown up which is exercising a considerable influence on agricultural research. This is the Indian Science Congress which since its inception in 1914 has steadily progressed and has now established itself as an important factor in scientific investigation in India. The Agricultural Section of the Congress not only affords a convenient meeting ground for workers interested in the subject but has initiated a number of joint discussions with the other sections which have done much to stimulate investigation and to widen the general outlook.

In 1919, an important change took place in the control of agricultural work in India. Agriculture in the provinces became a transferred subject and was placed in charge of an Indian Minister responsible to the new Reformed Councils which are composed of a majority of elected unofficial members. Shortly afterwards, the recruitment of officers by the Secretary of State ceased, the existing European members of the Provincial Departments being given the opportunity of leaving India on

proportionate pension. A large number took advantage of this privilege and were replaced by young recruits. These changes, coupled with an intensive retrenchment campaign, an aftermath of the Great War, lowered for a time the general morale and reduced the output of the Department. Further, a great deal of criticism on the conduct of the work was heard in the Councils, expenditure was curtailed and it was frequently urged that all the government farms except those dealing with definite experiments, should pay their working expenses and if possible make a profit. This phase is now passing. The interest taken in the development of agriculture by the Secretary of State and the Viceroy coupled with the investigations of the Royal Commission on Indian Agriculture (which commenced work in India in October 1926 and completed its labours in April 1928) have produced a change in public opinion. A growing interest on the part of the intelligentsia in the development of India's greatest industry, is taking shape. At the same time the Councils are settling down to constructive work and the volume of destructive criticism is diminishing. There is every indication that the proposals of the Royal Commission for the uplift of rural India are receiving careful consideration all over the country. Should they secure the active support of the Ministers and of the Provincial Councils, there is little doubt that agricultural research will enter on a new phase.

Such in brief is the history of agricultural research in India from 1903 up to the time of writing (August 1928). The reader interested in further details will find in an appendix (page 87) a brief directory of the Imperial and Provincial Departments of Agriculture which will enable him to get into touch with the administration, the research officers, the experimental farms, and the staff working in the districts.

The total expenditure incurred by the Imperial and Provincial Departments of Agriculture during the financial year ended 31st March 1927 amounted to Rs. 1,31,23,821; the total receipts for the period were Rs. 27,73,648. The net expenditure for the year 1926-27 was therefore Rs. 1,03,50,173 (£776,263). This works out

at about 9 pies per acre of the cultivated area and 8 pies per head of population in British India.[1]

From the point of view of the ideal instrument for present day needs it must be confessed that the Agricultural Department requires a considerable amount of reconstruction.

On the research side, the chief problems now awaiting solution and the conventional method of approach by means of the separate science bear little relation the one to the other. The attack is made on too narrow a front. In the early days of the department it is true that the approach by means of the single science yielded a large number of useful results on which the whole edifice now rests. The end of this preliminary harvest is, however, in sight. The investigators are now face to face with new questions which cannot be solved successfully by the old methods. The great problems underlying crop-production and animal husbandry are much wider than the limits of any one particular science. They require for their solution a considerable knowledge of several sciences, a long experience in research work as well as a first hand acquaintance with agriculture itself. If all this is not brought to bear simultaneously, the result can only be the accumulation of more data which may or may not be useful to some master-builder of the future.

Viewed from the standpoint of the development of the country-side as a whole, the great weakness of the work in the districts is that it has never covered the whole subject. Although much valuable work has been done, particularly in seed-distribution, finance has been omitted altogether and the human factor has been dealt with to a very small extent. Much more attention should have been paid from the very beginning to the village as a whole, to its people, to their ideas, and to their general condition and outlook. A persistent effort should have been made, when the subject was discussed some fifteen years ago, to amalgamate co-oper-

[1] 12 pies = 1 anna; 16 annas = 1 rupee (1s. 6d.).

tive work[1] with agricultural demonstration and to evolve a system of co-operative demonstration for the villages in which the same agency supplies credit for the express purpose of carrying out improvements in production. Officers engaged in extension work should confine their activities to the village and its people and should not attempt to unite this with investigations, which are best carried out at an experiment station.

To cope with the situation as it exists to-day a good deal of reorganization is necessary. The experiment station side of the work will have to be very considerably strengthened. Investigation will have to be restricted to questions which really matter. On the extension side, rural development will have to be taken up as a whole and not piecemeal. These matters are dealt with in greater detail in the remainder of this volume.

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[1] The cultivators of rural India come in contact with the co-operative movement mainly as members of the primary societies. These follow the plan originally devised by Raiffeisen in 1849. This reformer brought together small bodies of peasants into societies for the purpose of obtaining credit by pledging their unlimited liability. The funds so obtained were strictly supervised by an elected committee who gave their services gratis. A primary agricultural co-operative credit society is composed of a number of individuals who combine together to obtain the credit necessary for their agricultural operations. To make this possible each becomes liable for the debts of the society to the extent of the whole of his assets.

A general account of the co-operative movement in India is to be found in the first volume of the *India of To-day* series published by the Oxford University Press. The progress made up to the beginning of the Great War was dealt with in the *Report of the Committee on Co-operation*, Simla, 1915 (known as the Maclagan Report). The student will find the latest details on the subject in the *Bombay Co-operative Quarterly*, in the *Proceedings of the Ninth Conference of Registrars of Co-operative Societies in India*. Calcutta, 1926, and in *Statements Showing the Progress of the Co-operative Movement in India during the year 1926-27*, Calcutta, 1928. In these various publications practically everything which bears on the subject can be traced without difficulty.

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CHAPTER IV

SOME RESULTS OF AGRICULTURAL RESEARCH

In this chapter an attempt will be made very briefly to indicate the main practical results which have been obtained in India since 1904, when the present Department of Agriculture started work. Those relating to crops and soils have recently been summarized in *Crop-Production in India*, in which some suggestions relating to future work have also been made. Many matters relating to cattle and to the diseases which afflict them have been discussed at a number of conferences which have been held in recent years. In the space available it will only be possible to mention the more important developments. The reader who wishes to obtain further details should study the literature cited on pages 55-6 and also consult the twenty-three volumes of the *Agricultural Journal of India* which so far have been published. Matters connected with animal husbandry are now dealt with in a new quarterly—*The Journal of the Central Bureau for Animal Husbandry and Dairying in India*—the first number of which appeared in April 1927.

CROPS

Although the organization of the Indian Agricultural Department includes research in most of the sciences bearing on the subject, nevertheless practical results have been more readily obtained in some branches than in others. All advances in Indian agriculture must necessarily proceed from the basis of small holdings, cultivated by a peasantry for the most part in debt. The line of least resistance has, therefore, to be taken. This lies in providing the cultivator, at moderate rates, with seed of better yielding varieties of the crops grown, so that production can be increased without any extra expense on his part. In this way, the position of the peasant is improved and, what is still more important,

confidence is established. Hence the great attention which has been paid to the distribution of seed of the improved varieties of the chief crops of India which have been isolated in recent years and the immediate success of this work. At a conservative estimate, made in 1926-27, these improved varieties covered no less than 8,815,555 acres. If twelve rupees an acre is taken as the average additional profit made by the adoption of these varieties, the annual value of the crops of India has been enhanced by over ten and a half crores of rupees (£7,875,000). Moreover, this amount is rapidly increasing. Important as this result is, it must not be forgotten that much greater progress could have been made but for one great obstacle, namely, the fact that the Indian cultivator is uneducated and cannot be reached by the printed word. How greatly the illiteracy of the peasant has hampered the work of rural development in India will be realized if the spread of the new varieties of Pusa wheat is compared with that of Marquis in Canada and the Northern States of the Union. As regards the degree of improvement there can be no question. The Pusa varieties are a much greater advance on the average types grown in India than Marquis is above the kinds it replaced in North America. In fifteen years the Pusa wheats have covered a little over 2,000,000 acres. In about the same period, the area under Marquis has exceeded 20,000,000 acres.

The chief characteristic of the crops of India is the great number of different kinds found in almost every field. This mixture of varieties was of little importance when the chief business of agriculture was to feed and clothe the indigenous population. Since the opening of the Suez Canal, conditions in India have changed and improved communications have now brought the fields of the cultivator in touch with the markets of the world. These markets provide raw material for various industries which demand a uniform product and if possible one which does not vary much from year to year. In replacing the mixtures now grown by more efficient types, care must be taken to supervise the distribution of improved seed so that the mixed country crop is replaced over a large area by a single type. This should give a better

yield and if possible command an enhanced price. To obtain these new types, three methods have been adopted—acclimatization, selection and hybridization. With a few exceptions, such as the successful introduction of S48 sugar-cane in Rohilkhand, acclimatization has proved a failure in India. The isolation of the best constituents in the indigenous mixtures has been much more successful and has also cleared the ground for hybridization—the method by which the maximum results are likely to be obtained in the future. After an improved variety has been obtained, the next step is to organize and put into force an intensive method of seed distribution by means of which the country crop can be systematically replaced by the new type. When the area is large enough and the new type begins to reach the markets in quantity, the interest of the trade is enlisted with a view to creating a constant demand for the improved product. In the following paragraphs, some of the more striking results obtained on crops are very briefly reviewed. A much more detailed account of these matters will be found in *Crop-Production in India.*

Fibres. The area under cotton in India is in the neighbourhood of 25,000,000 acres; the total yield varies from five to six million bales (each 400 lb.). The bulk of the crop comes from the black soil areas of the peninsula which produce the grade known as Oomras. On these soils, cotton is raised on the natural rainfall and the growth period is short. These conditions exclude a really long staple and favour rapidly maturing types. The main problem of this tract is to increase the yield and to unite with this character a somewhat better fibre. In Gujerat, in the southern areas of tha Bombay Presidency, in Hyderabad and in parts of Madras, the natural conditions enable a longer staple to be grown. In these areas, the improvement of the fibre becomes a much more important matter than in the Oomras tract. There are, therefore, two main cotton problems in India—the increase in the yield per acre in the Oomras tract, and the improvement in quality in the areas with a longer growth period. At the moment, more attention is being paid to the spread of better

Transporting seed-cotton to the gin

quality cottons in the longer staple tracts than to the extension of high yielding, short staple types on the black soils. The results of the various investigations on Indian cotton [1] are very encouraging and in 1926–27 the area under improved types exceeded 3,500,000 acres—about 14 per cent of the total area under this crop.

In the production of jute fibre north-east India possesses a natural monopoly which is not likely to be challenged by other countries. In 1927, the yield was estimated at 12,132,000 bales (each 400 lb.) raised on an area of 3,847,000 acres. The normal yield of fibre is 1330 lb. per acre. The main problem in the improvement of jute is to increase the yield rather than to improve the quality which to a considerable extent is said to depend on the environment. This undertaking has been successfully accomplished at Dacca. A high-yielding, disease-resistant type (D154) of *Corchorus capsularis* L., round-podded jute, and an improved type (Chinsura green) of *C. olitorius* L., long-podded jute, have been introduced into general cultivation. On an average, these selections yield 250 lb. more fibre per acre than the local varieties. In 1926–27 they occupied about 500,000 acres or thirteen per cent of the total area. The seed distribution schemes in this crop have been seriously interfered with by a shortage of seed due to the fact that although Bengal is eminently suited to the growth of fibre, the yield of seed is poor. It might pay to divide the jute industry into two parts—the production of the fibre in Bengal and the growth of improved seed in tracts like Rohilkhand and Oudh. The storage and distribution of jute seed present no great difficulties.

Cereals. Among the cereals grown in India wheat and rice have received most attention on the part of agriculturists. In both crops, successful results have been obtained and the seed of improved varieties is now being distributed to cultivators on a large scale.

The area under wheat is about 30,000,000 acres; the yield is in the neighbourhood of 9,000,000 tons. About

[1] These are published periodically by the Indian Central Cotton Committee.

three-quarters of the total produce comes from the drier alluvial tracts of north-west India. Most of the crop is consumed locally and even in favourable years not more than ten per cent is exported. The yield is almost everywhere limited by two factors—shortness of the growth period and an insufficient supply of combined nitrogen. In some seasons, the moisture in the soil is also in defect. The essential requirement in an efficient variety of Indian wheat is speed of growth. Types which cannot ripen a crop under unfavourable conditions are useless. A good deal has been accomplished in the improvement of wheat since the subject was considered in 1906. It has been found possible to unite in the same variety high yielding power, high grain quality, rapid growth, strong straw and a fair degree of rust-resistance. Schemes of seed distribution, suited to the needs of the cultivator, have been devised and put into force in the United Provinces and other parts of India. At a conservative estimate, made in 1926–27, the area under these new wheats was nearly 3,000,000 acres. The increased profit to the growers, at fifteen rupees an acre, amounted to over three million sterling a year. At the moment the most pressing problem in wheat production in India is the spread of intensive cultivation coupled with the reduction in the volume of irrigation water used in raising this crop. Ground has been broken in this direction. When the amount of organic matter in the soil is increased, yields of over thirty maunds to the acre have recently been obtained with only one watering. For example, at Quetta in 1919, an acre plot in good condition gave on the preliminary irrigation before sowing, supplemented by 6·77 inches of winter rain, 2,686 lb. of grain and 4,715 lb. of straw. At Shahjahanpur in the same year, an area of 3·4 acres of Pusa 12 after sugar-cane on the Java system gave 36·5 maunds per acre on one irrigation. A great deal remains to be done to show the cultivators how to obtain similar results.

Rice is the most important crop in India and covers about one-third of the total cultivated area. In 1926, the area under this cereal was 79,233,000 acres; the estimated

The Java System of Sugar-cane cultivation

yield was 29,636,000 tons. Over 90 per cent of the crop is consumed locally: except in Burma the export trade in this cereal is small. Land under rice seems to be able to manure itself provided the supply of water is adequate. Unlike most other cereals, large yields are produced by the same land year after year without the addition of any nitrogenous manure. In spite of continuous cropping, no diminution in fertility seems to be taking place; the gains and losses of nitrogen appear to balance each other. More important than the nitrogen supply is the question of drainage. The maintenance of sufficient permeability in rice soils, so as to allow of a slow stream of aerated water from the surface to the roots, is an important matter. The addition of green-manure and of various substances such as sodium sulphate, magnesium sulphate and superphosphate appear to be of service in this respect. Work on the improvement of the variety grown is being carried on at a number of stations—Dacca, Coimbatore, Mandalay, Karjat and other places. At the moment, the main plank of the rice platform consists in the isolation of all the promising unit species found in the ordinary crop and their comparison (as regards yielding power) under experiment station conditions. Breeding work is also in progress at Dacca and Coimbatore. The investigations on rice have been attended by considerable practical success. Heavy yielding types have been isolated, tested and made the basis of successful schemes of seed distribution. In 1926–27 the total area under these improved types was over 882,547 acres or about 1·1 per cent of the total area.

Sugar-cane. India is an importing country as far as sugar is concerned and every year has to spend large sums in the shape of exports to make up for the shortage. During the twelve months ending 31st March 1927 about 917,000 tons of sugar were imported into India. The estimated area under cane in 1926–27 was 2,920,000 acres; the average yield was about one ton of sugar per acre. Seventy-five per cent of the produce comes from a broad strip of the Indo-Gangetic plain, lying alongside the Himalayas and stretching from Gurdaspur

on the west to Darbhangha on the east. Contrary to expectation, the crop is of minor importance in tropical India. Two main problems are involved in the improvement of sugar production in India—the increase in the sugar produced on each acre of land and the reduction of the cost of each ton of cane grown. During and immediately after the Great War, when the world's supplies of sugar were greatly restricted, large profits were made in India by the cultivation of sugar-cane. This period of prosperity has come to an end. The increased areas under cane in Cuba and of sugar-beet in Europe have led to a period of over-production and of low prices. In spite of the protection afforded by an import duty, many Indian sugar factories have ceased to earn a profit. The only effective remedy for the present conditions is the reduction of the cost of production. Important steps have been taken in this direction. The Java system of growing cane in trenches, by which the yield per acre can at least be doubled is being introduced in the chief sugar tracts of the United Provinces by the Shahjahanpur Experiment Station. To obtain the most out of this method of cultivation, a new cane of Java origin, known as S48, is being widely grown in Rohilkhand and parts of Oudh. The net result has been the general introduction, in the chief sugar producing area of India, of intensive cultivation combined with an improved variety. It is only a question of time for this improvement to become universal. In a few years it should do much, assisted by the present import duty on sugar, to enable the industry successfully to withstand competition from other countries. Important work on the improvement of the indigenous varieties has been carried on at Coimbatore. At this station, new seedling varieties are being created. Thousands of plants have been raised of which a few—notably Co. 205, Co. 210, Co. 213, Co. 214 and Co. 290—have proved successful in North Bihar, in the neighbouring tracts of the United Provinces, in the Agra Division, and in the eastern Punjab. The introduction of these new seedlings in north Bihar is due to the efforts of the Sugar Bureau, which in addition provides the trade with the latest information

on prices and stocks. It was a fortunate circumstance that when the recent fall in the price of sugar took place, the growers had been provided by the Agricultural Department not only with an improved method of cultivation but also with superior varieties. But for this a much greater reduction in the acreage under cane might have occurred. In 1926–27, the area under improved varieties of cane in India was estimated at 207,989 acres.

Other Crops. Besides the work on fibres, cereals and sugar-cane, a number of other crops—oil-seeds, tobacco, fodder-crops, gram and millets—have been studied. In many cases the results are beginning to be adopted by the people. Notable progress has already been made in the case of ground-nuts, tobacco and fodder crops.

Ground-nuts thrive best on well-drained, open soils where the rainfall is well distributed. Self-fertilization is the rule in this crop and the species is made up of a wide range of types differing greatly in growth period, in habit and in yielding power. The problems involved in its improvement are simple—the isolation of rapidly maturing, disease-resistant types which suit the soil and moisture conditions of each tract and the provision, where necessary, of sufficient organic matter for rapid growth. By the introduction of new varieties of ground-nut in the early part of this century, the so-called *tikka* disease which did so much damage in Bombay and Madras was overcome. A number of foreign varieties were introduced and tested. The results were singularly successful. Not only was the industry saved but a large extension of cultivation took place in the chief centres of production—Madras, Burma and Bombay. The crop also spread to new areas—Bundelkhand, Orissa, the Central Provinces and Chota Nagpur. These earlier efforts have been followed in the last few years by a notable advance in Khandesh and north Gujerat where the acreage under rapidly-growing types of high oil-content is increasing. In 1912–13, the area in these two tracts was only 4,500 acres; by 1925–26 it had increased to 373,000 acres. The total

area under ground-nuts in India in 1926–27 was 4,292,000 acres—more than three times the acreage of 1918–19.

The area under tobacco in India is about a million acres of which about half occurs in Bengal and Madras. Two species are cultivated. In Madras, Bombay, Burma, Bengal and Bihar, where the climate is both warm and moist, ordinary tobacco, *Nicotiana tabacum* L., is grown. In the drier, colder regions of north-west India, where irrigation is essential or where, as in eastern Bengal, the growth period is shortened by the late subsidence of the rain inundation, *Nicotiana rustica* L., a robust, yellow-flowered species with a short growing period, predominates. Up till recent years, yield was the only matter of importance in tobacco growing in India. Except in the tracts where cigar tobaccos are grown—Rangpur in Bengal and Dindigul and a few other centres in Madras—little attention was paid to methods of curing or to the quality of the leaf. The main thing was to take off the ground as heavy a crop as possible and to include most of the stalk in the cured product. With the recent change in fashion from the hookah to the cigarette, combined with the establishment of modern cigarette factories, a demand for a cheap cigarette tobacco has arisen in India. This has been met by the provision of a type known as Pusa 28, a rapid and robust grower which gives a high yield of leaf of good colour, texture and flavour when cured with the smallest possible quantity of moisture in the country fashion. It is remarkable in its power of adaptation to widely different conditions and has done well, not only in Bihar but also in Burma, the Central Provinces, Central India and the United Provinces. Up to 1924, seed for over 250,000 acres had been distributed. With the recent reduction in the customs duties on Empire grown tobacco in Great Britain, the prospects of establishing an export trade in Indian leaf have materially improved. Provided the cultivator can obtain an immediate and adequate reward for increased quality, there seems no reason why this trade should not develop. Leaf with good flavour, texture and colour has undoubtedly been and can be

produced in India. The yield per acre however is likely to be less and the cost of production greater than is now the rule with the present coarse types. Moreover, better curing will involve more trouble and considerably more expense than the existing methods. The future therefore will depend on the satisfactory sale of produce of high quality, a problem which still remains to be solved in India.

A better supply of fodder is the foundation of the cattle question in India. Excellent breeds of work cattle and of buffaloes already exist; the problem almost everywhere is to fill their stomachs. For this reason an increased and increasing amount of attention is being paid to fodder crops. The great advantage of silage in providing an easily stored and palatable fodder for the dry season, when no grazing is available, is being brought to the notice of the people. New crops are also being introduced, of which berseem (Egyptian clover) is thriving in many parts of India. Introduced originally in Sind, it promises to do much in solving the fodder problem and also in improving the soil. Its rapid spread all over northern and central India has hitherto been hampered by the necessity of importing every year fresh seed from Egypt. In the plains, very little seed is set. Recently, however, an important step forward has been made. The cultivators in the North-West Frontier Province are now producing berseem seed for sale. If this supply proves adequate and an efficient system of seed-distribution can be organized, the spread of berseem is certain to be rapid. Only the fringe of two other important fodder questions has been touched, namely the intensive cultivation of fodder crops and the making of good leguminous hay in north-west India.

Soils, Cultivation and Manures

Soils. During the last twenty years much valuable work has been carried out on Indian soils, the results of which are scattered through the various publications of the Agricultural Department. It is impossible in the space available to do more than refer to the more important practical results obtained.

The preservation of the surface soil of the country naturally precedes any question of its improvement. This matter has already been referred to (pp. 12–16) and great stress has been laid on the damage done by the annual removal of fine soil by erosion. These losses are easily preventable. The run-off must be controlled by a system of shallow ditches and led to the natural drainage lines of the country. In the planting districts this matter is receiving attention. It has also been taken up in the Bombay Presidency where a Superintending Engineer is at work helping the people to carry out local schemes for the prevention of soil-erosion and for the proper regulation of the surface drainage.

Among the more purely chemical investigations on the soils of India those relating to the formation of nitrates are perhaps the most useful in indicating the directions in which higher yields can be obtained. They were carried out at Cawnpore and at Pusa and show very conclusively that there are two periods in the year when nitrification is most active—at the break of the rains and again at the beginning of the cold weather. In both cases, efficient soil aeration is a necessity for this process. Given a supply of air for the soil organisms and of organic matter in the right condition, the formation of nitrates is exceedingly rapid at both these periods. The result is a good crop if the sowings are timely and if a suitable variety is grown. The practical problem is to prepare a supply of fermented organic matter and to apply it to the soil at the right moment. In this matter the Indian cultivator has much to learn. His scanty supplies of manure are allowed to dry outside his house and are applied to the land in an undecayed and unfermented condition. After the seed is sown, the soil has to prepare this undecayed material at a time when all its energies should be devoted to providing the plant with food materials. Both these processes require large volumes of oxygen and thus compete for a substance likely to be in defect. The result is over-work and fatigue. Crop-production really consists of two processes which are best kept separate: (1) the preparation of food materials which should be done outside the field and (2) the growth

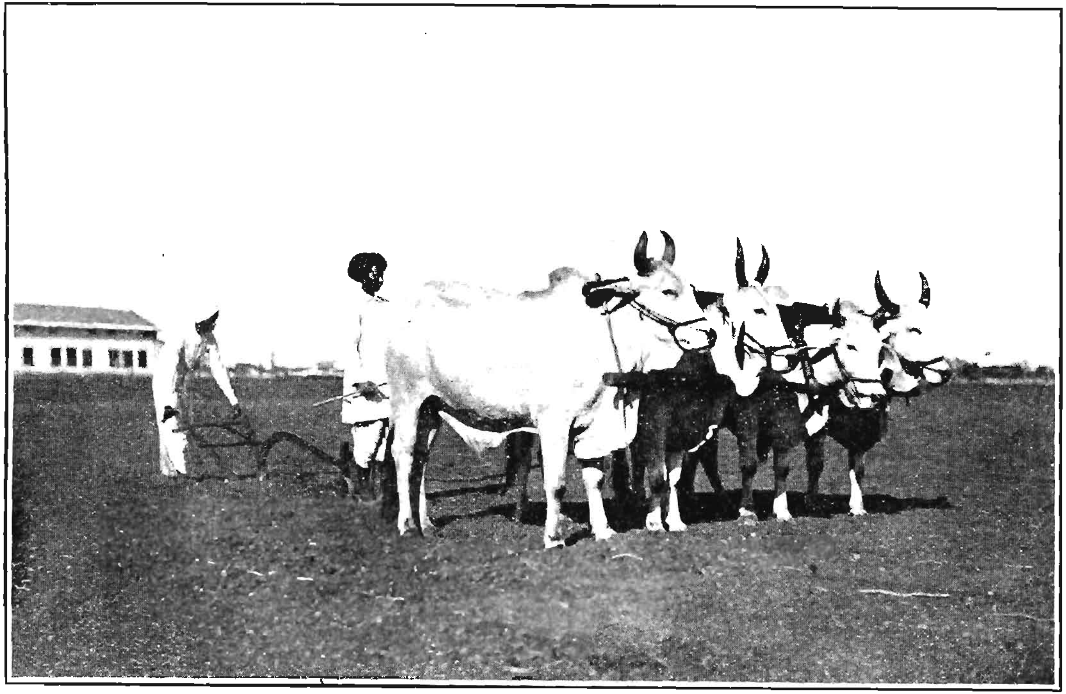
of the crop—the real work of the soil. The Chinese were the first to discover and to adopt this master idea. They go to infinite trouble to convert all sorts of refuse animal and vegetable matter into finely divided manurial earth ready for the use of the crop. This is incorporated into the soil before the seed is sown so that there is no loss of time and no harmful competition. The crop obtains all the nitrogen it needs, ripening is hastened and a good harvest is reaped. The proper preparation of animal and vegetable waste materials should be demonstrated without any further delay in every village in India.

One great disadvantage of the conventional methods of attacking soil problems must be mentioned. In general, these are too static: the results only relate to the conditions at some particular moment of time. The evidence so obtained is therefore difficult to interpret when considered in relation to the growth of a crop. It must always be realized that crop-production is a process extending over a considerable period in time and is the resultant of a number of interacting soil factors such as the supply of moisture, the composition of the soil atmosphere, the nature of the soil population as well as the supply of dissolved salts. Some method of investigation which can integrate the effect of the various factors on the growth of the plant is therefore required. A somewhat novel way of studying soil problems is now being employed in India. This consists in using the plant itself to indicate the general soil conditions and its deficiencies. For this purpose, a knowledge of the distribution of the root-system and of the zones of root activity throughout the life of the crop are needed. This information has then to be correlated with the above-ground development of the plant. In this way soil studies resolve themselves into problems of adaptation—the relation of the plant to its environment. One great advantage of the method is that the investigator can obtain a continuous record of events from the time the seed is planted to harvest time. Such studies have indicated a very important factor in soil chemistry in India which is operating both on the alluvium and also on the black soils of the peninsula. This is the development of an intense colloidal condition

which often prevents percolation altogether. The pore-spaces become water-logged for long periods and a condition is established which profoundly affects both the bacteriology and the chemistry of the soil. The plant reacts immediately. At first there is a cessation of root action followed sometimes by the destruction of the absorbing system except that on or near the surface. In one of the cases investigated, namely Java indigo, the establishment of the colloidal condition was eventually followed by the general wilting of the crop. In the case of cotton on the black soils a similar factor brings about a cessation of growth and leads to the postponement of flowering till late in the season.

The improvement of surface drainage is not sufficient in itself to remove the colloidal condition. Something more is required. Very promising results have been obtained by the use of *karanj* cake and other similar substances which help in maintaining the soil texture during the rains. Besides the supply of food material for the crop, the preservation of the natural texture of the soil during long periods of wet weather is therefore one of the chief problems in Indian agriculture.

Cultivation. The great contrast between the shallow cultivation of the Orient and the deeper tillage in vogue in Europe has exercised a profound influence on many of the improvers of Indian agriculture. At first sight it seems so certain that the work done by the primitive Indian plough, which only pulverises the surface, must be inferior to that accomplished by an implement which works much deeper and also turns the soil upside down. Hence the persistent efforts which have been made to induce the cultivator to adopt soil inverting ploughs in place of his old-fashioned wooden implement. The general introduction of the new method has been hampered by the limited strength of the work cattle who find soil inversion involves far too much work. As horses are not available in India for really deep tillage, the steam engine and the tractor have been introduced. It must be confessed that the response of the people to these innovations has been disappointing. Soil inverting ploughs have not been adopted generally to anything like the same



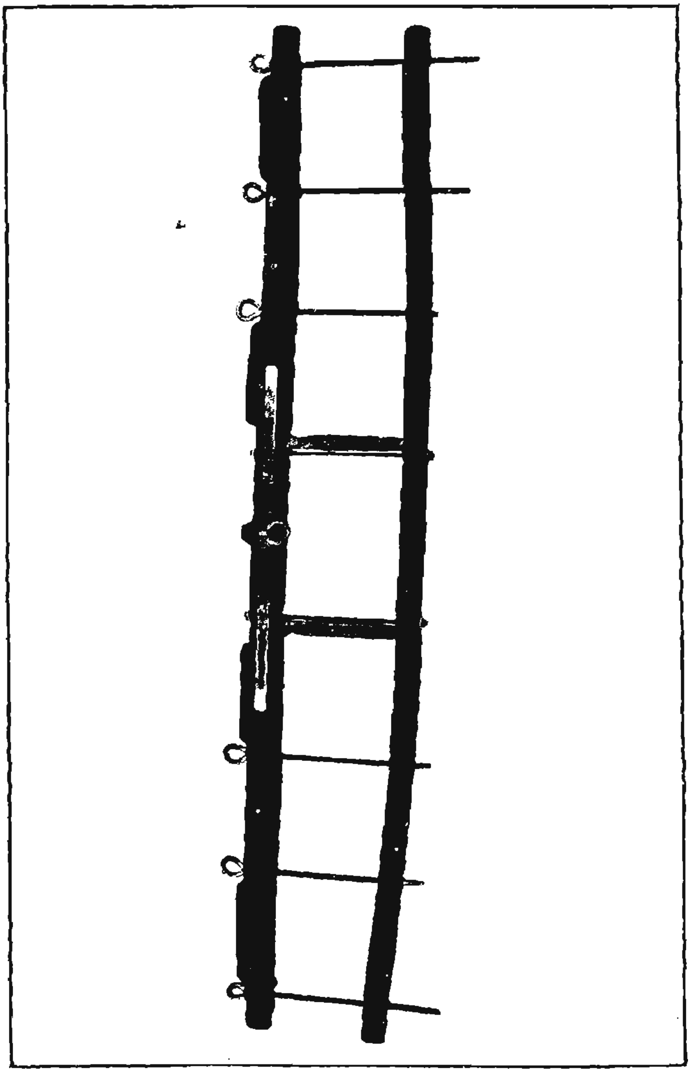
The eradication of *kans* (*Saccharum spontaneum* L.)

extent as some other devices of the West—the sewing machine, the safety bicycle and the cheap American car, all of which cost much more money than an iron plough. In his attitude of aloofness to the soil inverting plough and to power cultivation, the cultivator may after all be in the right. The matter needs a very careful and a very critical study. Soil inverting ploughs cost more than country ploughs and moreover often do great harm by disturbing the levels of irrigated land and by interfering with the surface drainage in the monsoon fed areas. The question naturally arises—Is soil inversion really needed in India ? This process has been developed in Europe for two pnrposes: the destruction of the weeds of stiff land by cutting off the light and the exposure of the soil to the pulverising effect of the frosts of winter. In India, neither of these factors is of any importance. If weeds can be uprooted in this country, the sun kills them at once: soil inversion is not necessary for the purpose. Dryness and heat take the place of frost in improving the tilth. Nevertheless deep cultivation is needed in India, particularly in connection with the eradication of deep-rooting grasses such as *kans* (*Saccharum spontaneum* L.) and in cleaning the land. It must however be carried out by an adjustable sub-soiler which does not disturb the surface levels. The power needed for such deep sub-soiling must be within the means of the people. The problems of *kans* eradication and of deep cultivation have recently been dealt with in central India by the introduction of an adjustable sub-soiler drawn by four oxen walking abreast in a single yoke. By this means deep cultivation to a depth of eight inches is possible without soil inversion and without the use of steam engines or tractors. These results also suggest the solution of the problem of improved cultivation in India and the correct design and use of the iron plough. Most of the soils of India need an adjustable iron implement which works on the same principle as the country plough but which can be used for shallow, intermediate and deep cultivation. It must also be capable of being drawn by the ordinary cattle of the country. The *Kans* eradicating ploughs in use at Indore fulfil all these conditions and can

be used for surface, shallow, intermediate and deep cultivation without any interference with the surface levels. By the addition of two mould boards these ploughs became useful ridgers.

The implements used by the average Indian cultivator, although effective in their way, are capable of much improvement. In tracts like Gujerat for example, great progress has been made by the people themselves in working out methods of rapid interculture suited to the soil and moisture conditions. The root of the matter in this tract is speed. A fast and powerful breed of work cattle has been developed. The crops are grown in straight lines; suitable implements for interculture have been devised. What has been accomplished by Gujerat must be done for the people in many tracts of India. For each set of soil conditions more efficient implements must be designed. The practice of growing crops in lines with interculture should become universal, particularly in the irrigated tracts. In the Punjab, where there is often insufficient labour for reaping the wheat crop, bullock drawn reapers have been introduced to meet the difficulty. On the alluvium, simple adjustable harrows for breaking surface crusts are beginning to be taken up in the United Provinces and the Punjab. In the former province, one of the greatest needs is a spring-tine cultivator for keeping fallows clean and stirred during the rains. Once the people begin to adopt these implements, mass production and sale, on the lines worked out by Mr. Henry Ford for his cheap motor car, will be needed in India.

Manures. Generally speaking, all attempts to solve the manurial problems of India by means of the conventional methods of the West have proved a failure. Outside the estates of the European planters and the Government farms, the consumption of artificial manures is negligible. Until quite recently the sulphate of ammonia produced on the Indian coal fields, was exported to Java. This want of success is largely due to the fact that artificial manures do not supply what Indian soils really need, namely, fermented organic matter in a finely divided condition. By demonstrating the



advantages of green-manuring on open, well aerated soils this cardinal defect has to some extent been met, but a great deal more remains to be done on this subject.

In spite of the fact that much of the cow-dung is burnt, the solution of India's manurial problem is now in sight. What is needed is the concentration of all the available resources of the Agricultural Department on the proper utilization of every form of crop residue. These must be converted into finely divided organic matter by the methods in vogue in China, Korea, and Japan which have been so vividly described by King in *Farmers of Forty Centuries*. To accomplish this, the various plant residues are first broken up so that absorption of oxygen and water is easy. They are then mixed with earth, a little cow-dung or urine earth (to start the fermentation), wood ashes and water. In a short time the compost heap is transformed by the cellulose-destroying organisms into finely divided organic matter ready for rapid nitrification. This is exactly the material the soils of India require for producing heavy crops. Ordinary weeds, water-weeds like the water-hyacinth and green crops like *Sann* (after they have been withered) yield a similar product. By the application of Chinese compost at the rate of ten carts per acre the yield of cotton at the Institute of Plant Industry, Indore, has been more than doubled. It is only a matter of time and effective propaganda for these methods to be taken up generally all over the country. Two guiding principles must be clearly kept in view in this work. In the first place, the fields must not be overworked. The soil cannot ferment raw organic matter and grow a crop at the same time. These two things must be kept separate. The preparation of food materials for the plant must be carried on outside the field as in China. In the second place, the aim should be to introduce small fragments of finely divided fermented organic matter, ready for nitrification, into as many of the pore-spaces of the surface soil as possible rather than to add so many pounds of nitrogen, potash and phosphate to the acre. The fine state of division of the manure at the time of application is perhaps of more consequence than the amount added.

These two principles are most important because crop-production is a process in time and the period available for effective growth is severely limited. Everything must be ready for rapid development the moment the seed begins to germinate. Any delay is fatal and is paid for by a reduced yield.

IRRIGATION

As a reliable supply of irrigation water is the first condition of increased production in India, the agricultural engineers have devoted themselves to the improvement of wells and to the introduction of small oil engines for lifting water. In this work very satisfactory progress has been made. The supply has been increased in a large number of cases on the alluvium and also in peninsular India by connecting ordinary wells with the great subterranean supplies by means of a simple tube or by a circular passage in the rock. The water-supply of the well is now practically inexhaustible and the installation of a suitable engine and pump becomes a practical proposition. Recently this improvement has been carried a stage further. A form of irrigation, intermediate between the perennial canal and a good well, has been developed. This is the strainer tube-well, a device by which the water in the deep-seated layers of coarse sand can be raised to the surface by a pump driven by an oil engine. These installations are often 250 feet in depth and are capable of watering 200 to 400 acres. When cheap current becomes available in the eastern Punjab, there is certain to be a great development of this form of irrigation and it is not unlikely that the raising of water by cattle power from innumerable small surface wells will then give place to a few strainer tube-wells, each commanding several hundred acres and operated by suitable motors. When the time comes it will be interesting to see whether the best form of control will be of an official character or by the people themselves, grouped into some form of Co-operative Irrigation Society.

The economics of the tube-well is a subject ripe for investigation. A balance sheet, in which the capital

cost and working expenses of the installation are contrasted with the increased value of the crops and of the land, would be an interesting document. If the water is used with judgment, an increase in fertility should result and the tube-well would then furnish a powerful argument for the investment of money in the development of the soil of India.

The discovery of the most effective method of using irrigation water has been greatly neglected in India. Under present conditions, canal water is assessed according to the area irrigated and according to the crop grown. This leads to the waste of valuable water and, what is far more serious, to the gradual destruction of the natural fertility of the land, the rate of deterioration depending on the amount of over-watering and on the absence of rest from surface-flooding. Some system, in which the cultivator can be encouraged to use as little water as possible, and also to give the land a periodical irrigation-fallow, is required. The great advantage of resting the land between two irrigated crops is well seen in Sind where heavy crops of millets, which require large quantities of nitrogen, follow one another every two or three years without any manure beyond the intervening period of fallow. If a periodical rest from surface-flooding is not provided on fine alluvial soils, the fertility falls under intensive irrigation. At Mirpurkhas for example, the yield of wheat fell from 759 lb. per acre in 1908–09 to 372 lb. per acre in 1913–14 in spite of the rotation of crops combined with manuring. Further, when desert lands first come under irrigation, it is well known that fewer waterings are needed than are required in succeeding years. These results are a natural consequence of the loss of soil texture which follows surface-flooding on many soils. The soil particles, many of which are lenticular in shape, arrange themselves parallel to the surface and so reduce the total volume of the pore-space. This naturally diminishes percolation and reduces the air-supply of the soil. Rest from irrigation appears to have the reverse effect and to re-create the characteristic open texture of desert soils. The obvious remedy is to use less water and to allow, every now and

then, this natural recuperative process to have full play. This, however, must remain a counsel of perfection as long as water is sold according to the area watered. No incentive to use less is provided; the temptation to use the maximum is always in operation. Taking the long view, the trouble saved in ease of assessment is very dearly purchased by the deterioration of the land. Sale by volume is the obvious remedy. This, however, is impossible in practice unless the water is sold to the community in large parcels. For bulk sale, the first condition is an educated community capable of managing its own affairs. Nevertheless some improvement can be made in present methods. If each watering is charged for separately, the first step in water-saving will become possible. The well-known advantages of inundation, when followed by a period of rest, could then be introduced into a perennial irrigation system. The cultivators on the Canal Colonies would be able to take advantage of the fact that a very good crop of wheat can be grown on two waterings and that a fair crop is possible with only one.

Intimately bound up with the proper use of irrigation water is the problem of alkali land. In the canal-irrigated tracts of north-west India, large areas are to be seen on the surface of which a saline efflorescence occurs as a snow-white or brownish-black incrustation, known as *reh* or *kallar*. The former (white alkali) consists largely of the sulphate and chloride of sodium, the latter (the dreaded black alkali) contains sodium carbonate in addition, and owes its dark colour to the fact that this salt is able to dissolve the organic matter of the soil. The salts of alkali land are not poisonous to plants but they prevent growth by abstracting water from the roots. This leads to the wilting of the crop. The soil population is also affected—in a few years the land dies and becomes useless. No easy and inexpensive means is available for making it live again. Large stretches of this barren salt land already occur and with the spread of canal irrigation the area is increasing. One of the most urgent problems is to ascertain first of all the origin of the alkali condition and then to take steps to prevent it.

Once this has been accomplished, the present cultivated area commanded by canals can be secured and the spread of this evil stopped. As the pressure of population increases, methods of reclamation can be taken in hand in the case of the large stretches of mild alkali land which occur in parts of Oudh. Whether or not it will ever be possible to reclaim, at a profit, the worst cases of salt land is a matter for future generations to decide. At the moment the resources of science are insufficient to solve this problem in its intense form in the plains of India. The game is not worth the candle.

Animal Husbandry

In the improvement of Indian cattle there is at present little to record. A great deal has been written on the subject in the past but only in recent years has there been any serious effort to study the subject and to devise simple improvements which are within the means of the people. Two great obstacles in raising the standard of the work cattle in India must be faced at the outset. The cow is a sacred animal. In the improvement of the breed by modern selection methods, there is therefore no method available, as in Europe, for the disposal of individuals which fall below a certain standard. In India all sorts of bulls and cows are permitted to exist and to breed. It becomes exceedingly difficult therefore to raise the general standard in any breed. The country is cumbered with poor cattle all of which consume valuable food. The second great obstacle is the need for maintaining two different species—oxen for work and buffaloes for milk. Attempts are being made at the Institute of Animal Husbandry, Bangalore, to produce dual purpose animals which will render the buffalo superfluous but so far this has not been accomplished in practice. The earlier experiments for achieving this object by crossing Indian cows with imported Ayshire bulls have not proved a success. Although the cows from the first cross proved to be heavy milkers, they are very prone to diseases like rinderpest and foot and mouth disease, and the resulting oxen of the first and subsequent generations are poor workers. More

promising results are now being obtained in another direction. At several of the large cattle farms, chiefly at Hissar in the Punjab and at Madhuri in the United Provinces, the mass production of first class bulls for distribution to the zamindars is being taken in hand. These are taking the place of the sacred bulls of old India and are proving of great use in helping to maintain the best breeds of Indian work cattle. Results of promise are also being obtained by the introduction of silage and by the better cultivation of fodder crops. In addition, detailed studies are being made of the chief breeds of cattle. A special laboratory has been established at Bangalore for the study of foods and feeding. There seems every prospect, therefore, that the volume of useful results on the work cattle of the country will rapidly increase. How far it will be possible to eliminate the buffalo and produce dual purpose cattle is a subject on which expert opinion is divided. It is a matter which will be settled by the results of experiments rather than by further discussion.

In the earlier years of the present century, the cattle problems of India were approached indirectly from the pathological side. It was felt that the chief need was to preserve the existing cattle force by inoculating the animals against rinderpest and other diseases. Acting on this principle, a well equipped Institute for the manufacture of various sera has been developed at Muktesar. In the provinces, Civil Veterinary Departments and Veterinary Colleges were also founded. As in the crops of India, the cattle problem was first approached from the disease aspect. It will be interesting to see how researches on the live stock of the country develop in the future and whether the various sections of the subject—breeding, feeding, milk-production and disease—can be welded together into a single branch of agriculture, namely animal husbandry, or whether the present separate sub-divisions of the subject will persist. Agriculture in India as in other countries falls into two main divisions—crop-production and animal husbandry. The evils which result when investigations follow the artificial sub-divisons of science rather than the problem

itself are well known. One of the things to avoid in any future work on Indian cattle is fragmentation.

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CHAPTER V

THE HUMAN FACTOR

The experience of the last twenty years in the development of Indian agriculture has firmly established two principles. In the first place, the application of science to this ancient industry has shown that considerable progress can be made and that with better organization still greater developments are possible. In the second place, the most formidable obstacle encountered in making practical use of the results obtained at the experiment stations is the unfavourable economic and educational condition of the Indian village. These are the chief causes of the poverty, indifference and illiteracy of the cultivator. They have helped to establish a condition of chronic indebtedness and a mentality enslaved by superstition. When it is remembered that the men and women, on whom all developments in Indian agriculture must depend, can neither read nor write and therefore cannot be reached by any form of literature, there is little wonder that progress is so slow. Such developments as have taken place have been the result of demonstration and persuasion carried on by men touring in the Districts. At the moment, this is done mostly by two independent agencies—the Department of Co-operative Credit and the Department of Agriculture. The former provides funds; the latter useful ideas, improved seed, better implements and so forth. In cases where these two groups of activities have been directed by men of energy and initiative, the results obtained have been most gratifying. The most enthusiastic of these officers, however, would be the first to admit that up to the present only the merest beginnings in rural uplift have been accomplished.

One disquieting fact has been brought to light. Hitherto no widespread desire for a better life has shown

itself in the villages although there were some indications, immediately after the war, that this might be awakening among the more virile races of the Punjab. Nowhere have the people come forward, either directly or through their elected representatives on the Councils, with practical proposals for raising local funds for such objects as better roads, improved marketing facilities, efficient rural education and similar amenities. Everywhere it is the human factor which stands in the way of progress. It requires no argument therefore to prove that till the inhabitants of the villages of India can be awakened and till a general desire for rural uplift can be implanted in the people themselves, it must take centuries to effect any real and lasting development of rural India by such means as are now being employed.

The question therefore arises—Is it possible to deal more effectively with this human factor? The answer would appear to depend on the way in which this matter is tackled. If the subject is first carefully studied, if adequate attention is devoted to the recognition and enunciation of the principles on which future action should be based, and if this reconnaissance is followed by a determined and long-continued effort to educate both the present and future generations, there is every reason to believe that the undertaking will succeed. It must always be remembered that agricultural improvements require intelligence and care and that something more than the conversion of the individual is needed. The new methods must be welded permanently into the rural economy. If the educational level is not raised, it is impossible to achieve lasting results by mere demonstration except at ruinous expense. Without the general enlightenment which follows education, a fresh beginning will have to be made with each succeeding generation, and no secure foundation for future progress will be laid.

The problem of rural development in India reduces itself to this. It is not sufficient to apply science to Indian agriculture and to bring the results to the notice of the people. This is only half the battle. The people themselves must desire to make effective use of the

results and to improve their general condition. In other words, they must be educated and must be taught how to think for themselves, how to read for themselves and how to act as an intelligent and progressive community. There are other very weighty reasons, apart from the need for general rural development, why this should be attempted. The new constitution, which has recently been given to India, is based on an electorate—rural and urban. Practically the whole of the rural community is beyond the influence of the newspaper and of any form of literature. The village is, therefore, unable to take any intelligent interest in current events and cannot possibly exercise its proper influence on the future progress of the country. Ninety per cent of the population is to all intents and purposes disenfranchised. Nevertheless, this same population, as recent events have only too clearly shown, is peculiarly susceptible to agitation, which of late years has made the work of Government difficult. Everywhere this movement has been most effiective in the backward provinces and in the backward tracts. The time seems to have come when the subject of the mass education of the Indian country-side must be undertaken. The problem can be divided into two parts—the education of the adult and the education of the child. In this chapter an attempt will be made to review the present position and to offer some suggestions for the future.

The Education of the Adult

The problem of improving rural education in tracts where general poverty (combined with a low standard of production) is the rule, is not a new one. In the early days of the present century, the industrial and educational development of the southern states of America had fallen very much behind that of the north. At that time, rural conditions in the southern states resembled those which obtain to-day in the more prosperous areas of India. The population was poverty stricken and mainly agricultural. There was great backwardness both in education and in industries; the economic conditions

were generally unfavourable. The average earnings of the agriculturist of the south were only about fifteen per cent of those of the farmer of the northern states. The problem was how best to help the backward south.

The American people dealt with this matter in a thoroughly practical fashion. An unofficial body, known as the General Education Board, first made an educational survey of the south, state by state. The results were then discussed and monographs were prepared on the various educational aspects of the problem. In other words, there was a very thorough reconnaissance before the battle and before any actual money was voted. The Board found that "No fund however large could, by direct gifts, effectively establish a system of rural schools, that even if it were possible to develop such a system by such means, it would be a positive dis-service...........The rural school must represent community education, community incentive and community support, even to the point of sacrifice." It was, therefore, decided that it would be better to co-operate with the people and to teach them how to educate themselves than to foist upon them a programme of education from outside. In carrying out this policy, the following initial difficulties had to be overcome. "The people did not possess sufficient money. Adequate developments could not take place until the available resources of the population were greatly enlarged. School systems could not be given to them as they were not prosperous enough to support them. Salaries were too low to support a teaching profession. Competent professional training could not exist; satisfactory equipment could not be provided." All this was the result of rural poverty. The great bulk of the people were not earning enough to provide good schools. The prime need was money. The Board came to the conclusion that it could render no useful educational service till the farmers could provide themselves with larger incomes. They then went to the root of the matter and resolved that the first step in rural development in the southern states was to improve agriculture and to make the soil yield a higher dividend. In carrying out this policy the Board was at first advised

to address itself to the rising generation and to support the teaching of agriculture in the primary schools. After full consideration this plan was rejected. In the absence of trained teachers and of funds to pay them, such a scheme was impracticable. Further, it was considered unwise to force instruction in better agricultural methods on schools if the parents themselves did not realize the defects in their own methods. Until the public was convinced of the feasibility of superior and more productive agriculture, the rural schools could not be reconstructed: once the public was convinced and better able to stand the increased cost, the schools would naturally re-adjust themselves. "It was therefore deliberately decided to undertake the agricultural education not of the future farmer but of the present farmer, on the theory that, if he could be substantially helped, he would gladly support better schools in more and more liberal fashion."

The Board then set on foot an extensive enquiry as to the best method of showing the southern farmer how to increase his production. The man and the method were simultaneously discovered. The late Dr. Knapp of the United States Department of Agriculture was engaged to direct a system of Co-operative Farm Demonstration which proved singularly successful. The method employed and the results obtained should be closely studied by all interested in the Indian country-side. Production was doubled, the equipment of the farmers was improved, better houses were erected, and there was a marked change in the general surroundings of the home. The application of the principle of co-operation coupled with well thought-out demonstration work produced other results besides an increase in production and improvements in housing. The social and educational awakening of the South was one of the bye-products of the demonstration movement. The provision for schools steadily increased. In North Carolina and Arkansas for example, expenditure was more than doubled in twelve years and rose from 2,461,055 dollars in 1901 to 8,579,478 dollars in 1913.

There can be no question that the principles underlying the policy of the General Education Board of the United States apply with great force to Indian

conditions. In India as in the southern states, the essential rural problem is to help the future generation. This, however, cannot be done effectively unless the support of the present adult population is enlisted and until they are made willing partners in the enterprise. An attempt to force education on an unwilling and hostile population would only court failure and lead to the waste of money on a colossal scale. Something more than consent is essential. The people must be taught to desire better education for their children and better villages for themselves and they must also contribute a portion of the cost. Unless all this is accomplished, there can be no real progress and the tree will not take firm root in village life.

To a certain extent the problems of rural uplift in India have been dealt with on lines which at first sight closely resemble those adopted in the United States. The demonstration of agricultural improvements in the villages has been in progress for twenty years. The Civil Veterinary Department has been engaged in protecting the work cattle from diseases like rinderpest. More and more money has been devoted to the development of rural education and rural sanitation. Since its introduction in 1904, the Co-operative Credit Movement has increased in volume and impetus, particularly in the Punjab and Bombay. In the former province, villages are in existence to-day in which the evils attending the fragmentation of holdings have been removed with the consent of the people—a co-operative result which twenty years ago would have been considered impossible. There is, however, one vital difference between the methods used in the southern states and in India. In America, rural development was surveyed as a whole, studied as a whole, and dealt with as a whole. In India there has been a lamentable fragmentation of effort which has resulted not only in a great waste of public funds but has also deprived the movement of its effectiveness. Moreover, the horde of minor officials who now deal piecemeal with the problems of the villager is more likely to exasperate than to awaken him from his present attitude of indifference to all forms of progress. One of these visitors deals with co-operative credit, a second with

improved seed and new implements, a third comes to inoculate the work cattle against rinderpest, a fourth inspects the village school, a fifth preaches the benefits of better sanitation and the advantages of dispensaries and so on. All those are attached to independent departments between which there is often little or no liaison. Moreover, these various departments often have no working plan in common. How much more could be done with the same amount of money if the development of the country-side could be looked at as a whole and if the work could be conducted by a single efficiently staffed department working on a well considered plan with an eye to the future as well as to immediate progress.

It is pleasant to record that in one District in India, namely Gurgaon in the Punjab, a beginning has been made to awaken the villager on the lines adopted in the southern states of America. Thanks to the energy and initiative of Mr. F. L. Brayne, the late Deputy Commissioner, a scheme of rural development suitable for the adult cultivator has been drawn up and put into force. The defects of the average village, of its roads, homes and fields are set out in vigorous and compelling phrase. This is followed by concrete suggestions for improvement which are well within the means of the people. If persisted in for a period of say twenty years, and if adequate financial support is provided, there is little doubt that active propaganda on these lines, carried out by a single efficient department dealing with rural problems, would, as in the United States, have two consequences. Crop-production would at least be doubled; the villages would be improved and the ground would be prepared for a system of compulsory rural education to which the people themselves would be ready and willing to contribute. As in the southern states, the spear-point of the new movement should be a vigorous policy of co-operative agricultural demonstration work. The activities of the present independent departments, which now deal with the cultivator, should in future be carried out by *one* agency. In this way the people could be taught how to help themselves and how to appreciate and make

proper use of funds contributed by the State for the support of local movements. The gradual growth of a rural electorate, capable of intelligent co-operation with Government in the future development of India, would follow.

The Education of the Child

There is a remarkable unanimity among all those who have studied primary education in the villages of India. Everyone is in agreement that the present state of this question is most unsatisfactory and that we are confronted with a problem on which little progress has hitherto been accomplished. Nothing can be more depressing than the review of mass education in this country in Mayhew's recent work—*The Education of India.* This appeared in 1926 and its findings are amply confirmed by the writings of Calvert, Darling, Olcott and by the report of a commission of enquiry on village education which was published in 1920. In the following paragraphs full use has been made of these various works and particularly of Mayhew's account of the present condition of rural education.

Although much has been done for elementary education in India since Gokhale drew attention to this subject in the first decade of the present century, nevertheless no great progress in the battle against illiteracy has been achieved. Many schemes have been launched and much money has been spent. The Government of India's quinquennial review of education (1917-22) suggests that the number of people who can read a letter in the vernacular and write a reply thereto has not increased *pari passu* with the growth in expenditure. Mayhew considers this result is due to the fact that only the children of the literary castes are taking real advantage of the facilities now offered and that the attitude of aloofness and hostility of the villager towards education has not sensibly changed. This general result is confirmed by the Census report of 1921 in which it is suggested that in the population above the age of twenty there has been no advance in effective literacy during the

preceding ten years. An examination of the statistics of such rural schools as exist at the present time does little to shake the findings of the Census. Of the 685,665 villages in India about three-quarters have no schools at all. Ninety-two per cent of the population is still illiterate; half the members of the police force cannot read or write. The figures of enrolment in the village schools are of no real significance. The lower classes are crowded and there is a rapid falling off in numbers in the higher divisions. This is due to the fact that the parents regard the village school not as a place where their children can be taught how to read and write but as a crêche in which the infants can be deposited with safety. As soon as the boys are big enough to tend cattle and do other light tasks they are removed. They never learn to read and still less to write their own language. In the average village school there are no regular school hours; the teacher has to collect the children from their homes and there are no regular dates of admission. Such records of attendance as exist are often unreliable. In 100 schools checked in one day in the United Provinces, the total enrolment claimed was 8,303; the average attendance was 5,516; the actual day's attendance was only 4,903 (*Quinquennial Review*, 1917-22). If the total expenditure on these schools is divided by the number of boys who can read and write, a surprisingly high figure is obtained. The present cost of producing literates is far too great, much more than the country can possibly afford.

Irregular attendance and the high cost of the results obtained are not the only faults of the village school. The buildings are poor, badly lighted and ill-ventilated. The gravest defect, however, is the unsatisfactory character of that factor which is more important than anything else—the teacher himself. Miserably paid, often holding aloof from the people among whom his life is spent and without a well-defined status in the village, the lot of the average rural teacher leaves a great deal to be desired. When to these adverse factors are added the manifold defects inherent in the present voluntary system there is little wonder that the village schools

are totally inadequate instruments for the conquest of the illiteracy of rural India. The money spent on such a system can only result in inefficiency and waste.

What is now required is a resolute and well-sustained effort on the part of the State to assist local bodies in the solution of Indian rural education in a practical and efficient fashion. Many factors are now favourable. Education is a transferred subject in charge of Indian Ministers responsible to the Provincial Councils. In such matters as the conduct of rural schools, the people govern themselves and there is little interference from above. The Universities are pouring out every year vast numbers of graduates, for the great majority of whom there is no work. The necessity for making rural education compulsory is becoming generally recognized; a statutory basis for compulsion has been provided by legislation in almost every province. Local bodies have been authorized to prepare schemes within their areas, to introduce them if approved by the provincial government and to levy special additional rates for the purpose. In the United Provinces for example, the assistance to be given by the State has been fixed on a very generous scale, namely, two-thirds of the total cost; the remainder being raised by the local authority. In the Punjab, a serious effort in the introduction of compulsory primary education is being made. Many of the conditions necessary for a forward movement already obtain. What is needed is firm and wise guidance on the part of the State so that assistance from public funds is only granted to supplement and not to replace local effort.

The general aims of vernacular rural education have been throughly discussed. There is very general agreement that this should be confined to training the boys to think for themselves, to read for themselves and to act for themselves. As regards the curriculum of the village primary schools, the Director of Public Instruction in the United Provinces has recently summed up this matter as follows: "One school of thought would utilize the village school for the dissemination of useful information on such subjects as agriculture, sanitation, malaria, plague, hydrophobia, snake-bite, rent and revenue

law, co-operative banking, the silk industry and even the state of the yarn market. The other would confine instruction to the three R's, not even admitting drawing or clay modelling, observation lessons or geography." In the United Provinces, a middle course has been selected. This is designed to make a knowledge of the three R's the chief object of the primary school, at the same time aiming to develop the minds and to widen the interest of the children. Too much emphasis cannot be laid on the wise limitation of the curriculum of the primary school by insisting that the boys are taught to read, to write and to perform simple exercises in arithmetic before embarking on anything further. Any attempt to use the village schools for the teaching of agriculture or of industries would discredit them for all time in the eyes of the cultivator and of the village artisan. Teaching in these matters can be more effectively carried out by the parents themselves after the school-going age has been passed. There is nothing more tragic in India than the general failure of the agricultural school for young children and of the many attempts which have been made to begin vocational training at too early a period.

The most important factor in the rural school of the future must always be the man or woman who has to do the work. The success of the movement will therefore depend on the wisdom and courage shown in the investment of money in suitable human material and in its training. As the influence of the teacher in the village will largely depend on his standing with the cultivators, it is essential that the future schoolmaster should be drawn from the village itself and that he should live, dress and speak like the people among whom he will pass his life. His pay must be adequate and his position in the community must be one of honour. The school buildings and the playground should stand out as a model of neatness and of order. In the selection of the man, in the status that should be his due and in the building in which he has to work, the controlling authority should from the very beginning set its seal in no uncertain fashion on the importance it attaches to the education of the generations to come.

Too much attention has been paid in recent years to the financial aspects of compulsory education. Calculations have been based on the number of boys to be educated, on the 685,665 villages of India, on the number of teachers required and on the cost of the buildings. Such figures have no value for the reason that even if funds were voted to-morrow for compulsory village education in all the provinces in India, the only result would be the waste and misuse of money to an appalling extent. A well considered and critical survey of the whole problem must first be made. The general principles underlying future action must then be laid down in concrete form. Detailed schemes for each district must be drawn up in which all the factors bearing on rural development—races, languages, religions, prevailing castes, communications, markets and so forth—are considered. The selection and training of teachers is the next step, followed by the designing of suitable buildings and equipment and by the grouping of schools for supervision and inspection. All these essential matters must take time. Compulsory education is a comparatively new idea in India and will have to be applied gradually. A programme extending over some twenty years is the first condition for future progress. This must then be backed up by a strong endowment fund from which local schemes can be assisted and developed.

A great saving will be possible in establishing compulsory mass education in rural India if full use is made of American experience. In New England, it was formerly the custom to maintain in the country districts a large number of small, unsightly, dilapidated and ill-ventilated single-room schools in which a young, underpaid woman attempted to deal single-handed with an impossibly large number of classes. The attendance was spasmodic; the interest of the pupils was poorly sustained; after a time many ceased to attend. The only possible results of such a system were waste and inefficiency. As nearly 12,000,000 boys and girls were involved and rural disintegration with a well marked exodus to the cities began to set in during the latter half

of the nineteenth century, a remedy had to be found and an effort had to be made to provide the country child with an education comparable with that obtainable in the larger towns. In 1865, the State of Massachussetts passed a law authorizing the consolidation of country schools by which a number of small, ineffective institutions could be abolished and replaced by one central, well-equipped school. Four years later this was followed by a second law providing for the conveyance of the children to the central school at public expense. The first successful experiment in consolidation took place in the township of Concord. Twelve schools were united into one strong central school in the course of the years 1870-1880. Since then, consolidation has become operative to a greater or less extent in thirty-two States of the Union. To this list we may add Hawaii, the five provinces of the Dominion of Canada under the Macdonald movement, and parts of the Australian Commonwealth. Consolidation is also spreading in the southern states of the Union in spite of the fact that in this region separate schools for the two races have to be maintained and the rural population is very scattered and generally impoverished. In practically all states, the children are transported from the outlying areas to the consolidated school in four-wheeled waggons provided with side ventilation and a roof. These waggons are supplied by the local authority and are operated by contract. The results have been very successful. In the consolidated schools it has been possible to provide suitable buildings and efficient equipment, to employ a number of teachers, to maintain classes of the proper size and to extend the curriculum. The great gap between urban and rural education has in this way been reduced.

There is no reason why a policy of consolidation should not be followed in the rural areas of India. Two things are required—(1) the design of four-wheeled waggons to suit rural conditions, each holding from twenty to thirty children, and (2) the provision of funds. The various districts should first be studied and then divided into suitable areas each with its future central

school; the children from the outlying small villages could be transported to and fro every day in ox waggons which could be operated at contract rates. In this way a vast sum of money, otherwise devoted to the erection of a multitude of small schools, one in each village, could be saved and would be available for the purchase of waggons and for the payment of transport. In place of one poor little school in each of the 685,665 villages of India, there would be from 100,000 to 200,000 well-constructed central schools, each with suitable equipment, a number of well-trained teachers, and sufficient pupils to fill all the classes. Moreover, under such a system the cost of keeping the school buildings in repair, of supervision and of inspection would be considerably reduced. Great care will be needed in the selection of the sites of these central village schools. In determining this important matter the question of rural development as a whole will have to be considered and such factors as general rural transport, improved roads, better marketing facilities, more efficient medical assistance, must be taken into account. The consolidated school will do more in the future than teach the children. It will serve as the centre of progress of a group of villages. By its means such movements as Co-operative Credit, the Co-operative sale of produce, the establishment of better markets, the demonstration of simple improvements in agriculture, the distribution of improved seed, improved rural sanitation, better housing and better communications will be provided with a suitable meeting place. In consequence they should gain greatly in force and in impetus. The head teacher will eventually become an important personage in rural life. The people generally will come in contact with the Government in other ways than through the policeman and the tax gatherer. The villages selected for the central schools of the future would have to be prepared for their future responsibilities. A vigorous programme of Co-operative demonstration for the improvement of agriculture would be the first step. When this is followed by a widespread desire on the part of the people for the better education of their children

and when the locality is prepared to shoulder at least one third of the cost, the local authority should be ready to crown the movement by establishing a central school. In this way the people would feel that they had worked for this result and that it would never have arisen but for their efforts in the past.

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CHAPTER VI

SOME COMMUNITY PROBLEMS

The general introduction of a system of mass education will enable a number of communal problems to be considered. Up to the present, the work of rural development has been largely confined to what can be done for the individual villager, his oxen and his fields. The cultivator, however, does not stand alone. He is a member of a community with problems of its own. It is true the villagers are being assembled into groups by the Co-operative movement primarily with a view to freeing them from debt. This, however, is only the first step in integration so that the larger problems of the country-side can be attacked. Some of these community questions, such as the re-alignment and fixing of the holding; the installation of a general system of surface drainage; the development of intensive agriculture; the co-operative management and sale of irrigation water; the establishment and maintenance of definite grades of produce for the locality; the provision of better roads and their maintenance, must now be considered.

The Consolidation and Fixing of the Holding. In many parts of India, notably in the eastern Punjab and the Bombay Deccan, the improvement of the holding is rendered impossible by the fact that it is not a permanent unit. This state of affairs is due to fragmentation following the operation of the law of succession by which every male child inherits an equal share of every description of land. In the course of time, the fields of each owner become scattered all over the village area; the plots get smaller and smaller and in some cases become so narrow that cross-ploughing is impossible. In the Punjab, it is common to find a man with his land in twenty or thirty places. In one instance, Calvert

discovered a cultivator with his holding broken up into more than two hundred fragments. The evil results of this system are many and obvious. The greatest disadvantage is that the holding is not permanent. The incentive to progress and development, which is conferred by the possession of a fixed and definite area of land, does not therefore operate. There are minor drawbacks in addition. The irrigation of small isolated plots is almost impossible. Much time and energy are wasted on a scattered holding in getting to and fro; the possibility of friction with neighbours is increased, while the watching of the crops presents great difficulties. In the Deccan, Keatinge sums up the present position in the following words : " The majority of the farms are of the wrong size and the wrong shape, they are not permanent units and are not susceptible of orderly and adequate improvement. The majority of the farmers are deficient in skill and balance a low standard of endeavour by a low standard of living." The system combines all the disadvantages of the small holding with those of extensive agriculture. The individual fields are too small for the adoption of labour-saving devices; their scattered character and their want of permanence put out of court the introduction of intensive methods. As a bar to all progress, it would be difficult to discover a more perfect instrument. The division of the holding however cannot always be prevented. In the rain-inundated areas of the United Provinces, Bihar, Bengal and Madras, where two classes of cultivation occur side by side—rice on the low-lying areas and ordinary mixed cultivation on the higher lands on which the villages stand—it is not possible to consolidate the holding to the same extent as in the Punjab and the Deccan. Each cultivator in the rice areas needs two very different classes of land. In such tracts, all that can be done is to reduce the evil of fragmentation. It can never be abolished altogether.

Whatever the method adopted to deal with fragmentation, it is obvious that the first condition is the consent of the great majority of the cultivators. The question, therefore, arises: Is it possible with an illiterate peasantry to obtain general agreement on such a matter ?

Twenty years ago the answer would have been: Most emphatically no. To-day the position is much more hopeful. In the eastern Punjab, Calvert has recently succeeded in forming Co-operative Consolidation of Holdings Societies which have met with a considerable measure of success. In 1923, work had been carried through in 126 villages. Over 20,000 acres, divided into 35,000 scattered parcels of land, were consolidated into about 4,500 fields. In a recent paper, Strickland records still further progress. The benefits conferred by the re-arrangement are clearly recognized by the owners and cultivators. Improvements which were once impossible are now in progress. The great value to India of this Punjab experiment does not however concern the material but the psychological domain. If it is possible, under efficient leadership, to produce these results among uneducated peasants in a locality which has enjoyed less than a hundred years of settled government, how much more may be confidently expected when to these advantages are added the benefits of education ? The significance of Calvert's experiment lies in this. It holds out hope for the future and supplies the answer to those who say that results which depend on community effort in India must always be impossible.

Soil Erosion; Surface Drainage; Nitrogen. Once the holding of the cultivator has been fixed and he has been provided with a secure tenure, the inevitable results of ownership will begin to appear. Possession, in the words of Arthur Young, will always transform a desert into a garden. What are the natural stages in this process in India ? The first is to put the monsoon in harness and to place the cultivator in command. It is of course not possible to arrange what the rainfall is to be but a great deal can be done to regulate it for the benefit of agriculture after it reaches the ground. The first step is to provide each locality with a suitable system of surface drainage so that there is no loss of fine soil by erosion, no water-logging by the run-off and no waste of water. The soil must be retained. The rainfall must be given time to percolate into the soil. The surplus must be conducted either to the rivers and drainage lines, to the rice areas or to reservoirs where it can be stored. At present there is

practically no drainage system in rural India and almost nothing is done to control the run-off. Such an installation is impossible for each separate holding. It is a matter for the community and will often require the services of the engineer. Up to the present the civil engineer has been utilized in Indian agriculture mainly for the construction and working of canals, by which the waters of the great rivers are led to the fields. The reverse process, namely, the scientific removal and disposal of the surplus rainfall, has often been left out of account. Drainage problems offer opportunities for the engineer at least equal to those presented by irrigation. Vast areas of the peninsula require a scientific scheme of surface drainage just as urgently as the deserts of the Punjab and Rajputana need irrigation water.

The benefits of the scientific control of the rainfall will only begin with the prevention of erosion and the better utilization of the rainfall. Surface drainage is the foundation of the solution of the nitrogen problem. Every year an enormous quantity of combined nitrogen is destroyed by the water-logging of the pore-spaces of the soil during the rains. This cuts off the air-supply, and establishes an anærobic soil flora which must obtain its oxygen partly from the nitrates in the soil. The process is known as de-nitrification and results in the annual loss of produce worth crores of rupees. Another consequence of this water-logging is the destruction of the soil texture which in turn interferes with rapid and adequate root-development. It is little use attempting to remedy this state of affairs by adding more manure. Such a proceeding may increase the losses. Until a suitable system of surface drainage is in working order there can be no real and lasting solution of the nitrogen question in India.

Drainage is therefore the first step in increasing crop-production. From the nature of things it is a community enterprise in which the lands of the village must be looked at as a whole. Drainage maps for each locality must be prepared so that the surface drains, embankments, reservoirs, roads and railways can all be considered together and laid out to the best advantage. Once this is done much more will be got out of the

Pusa 12 grown with one watering at Shahjahanpur

monsoon, the cultivator will be placed in command, the present natural fertility of the soil will be fully utilized and the door will be opened for the next step in advance—the general introduction of intensive cultivation.

The Introduction of Intensive Agriculture. The most suitable areas in which the present extensive methods can be converted into an intensive system appear to be the canal irrigated tracts where the water-supply is fully secured. At the moment, a canal is regarded either as a means of protecting the area commanded—from calamities such as scarcity or famine—or as an outlet for the surplus population of congested districts. It is rare to find the provision of water by the State looked upon as one of the essentials for the introduction of intensive agriculture. With an assured water supply, such as is now provided by the canals of the Punjab and the United Provinces, the people are content with the meagre results of extensive farming. Every year crores of rupees worth of potential crop-production in these two provinces are literally thrown away. The only other things besides water required for the introduction of an intensive system are varieties which respond successfully to better soil conditions and a supply of organic matter. The increase in production brought about by this means is extraordinary. The average yield of Pusa 12, gram and sugar-cane obtained under intensive cultivation at Shahjahanpur for the seven year period 1915-22 are given in maunds per acre in the next table:—

AVERAGE YIELDS AT SHAHJAHANPUR UNDER INTENSIVE CULTIVATION

Crop	Shahjahanpur	Average yield obtained by cultivators
Wheat ...	30·3	15·2
Gram ...	24·1	11·6
Sugar-cane ...	841·0	345·4

Pusa 12 grown with one watering at Shahjahanpur

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These yields were obtained by the addition of organic manure, containing approximately 100 lb. of nitrogen per acre, to the sugar-cane crop once in the four-year rotation. The figures show that crop-production under canal irrigation in the plains can be placed on a higher plane. Similar results are also possible on the rain-fed areas of the peninsula.

The Co-operative Distribution and Sale of Water. Although a supply of soil moisture for the crop is the most important factor of all in increasing production, nevertheless the methods of distribution and sale of water in India are exceedingly unscientific. In the canal-irrigated areas, the distribution of water requires the services of an army of minor officials, whose main duty is to assess the water-rate according to the area irrigated. The cost of this system is borne by the cultivator and in the aggregate must run to many lakhs of rupees a year in a province like the Punjab. This is not the only disadvantage. Assessment according to the area watered leads to over-irrigation and to the gradual destruction of the natural fertility of the land. The ideal system an alluvial soils is to use as little water as possible and periodically to rest the land from surface-flooding. To achieve this the sale of water by volume or, in the first instance, according to the number of waterings, is obviously the method to adopt. In this way the cultivator would soon begin to save water and so reduce this item of his expenditure. If, therefore, canal water could be sold in bulk to the village, great economies would follow. An army of superfluous officials could be disbanded, the village community would be provided with an opportunity to practise the art of local self-government and the present supplies of canal water could be made to command a larger area and produce an increased revenue. A similar communal system of distribution could be adopted in the case of strainer-tube wells, operated by cheap electric current, when the time comes to instal such devices in the eastern districts of the Punjab where the irrigation water is now lifted by cattle from a multitude of small wells.

The Grading and Marketing of Produce. In the

introduction of the seed of improved varieties of crops what may be described as the seed-depôt stage has been reached in the more advanced provinces. In the United Provinces, for example, a network of carefully designed and well-built seed-stores is being provided as fast as funds permit, the aim of this important movement being to establish one of these depôts in every *tahsil* of the province. The seed is kept in these stores between crops and sold at sowing time to the cultivators. In this way a number of fixed stations have been provided for the staff of the Agricultural Department. These depôts are proving of great value in the work of replacing the mixture of inferior types now grown by a pure variety of higher yielding power. It will be obvious that this excellent system can only yield optimum results provided it is not abused. If to save the trouble of storage, the same growers, year after year, draw their seed from these stores the rate of replacement of the country crop by the new kind will be far slower than if the depôt is used only at the beginning and if afterwards the cultivators store their own seed. As far as possible, the depôt ought to supply a fresh set of customers every year. The storage of seed in suitable metal containers by the people themselves should form a part of all schemes of seed-distribution. If a supply of cheap galvanised seed bins with air-tight, dished-in lids could be supplied with the seed, a further step in seed-distribution could at once be reached.

Seed distribution schemes affect the community as well as the individual. The grower of a few maunds of a new variety of wheat cannot obtain the real price for his produce unless his small parcel of seed is placed in touch with the markets of the world. To bring this about several conditions must simultaneously be fulfilled. The seed must be available in quantity, the supply must be regular and reliable from year to year and there must be buyers. To make this possible the village and then the locality must produce one variety. Buyers will then be attracted: competition for the produce will follow. The price will rise. All this can be achieved only by community effort on the part

of an enterprising population sufficiently educated to think and to act for itself. In this way definite grades of produce can be established in India and some of the more favoured localities will then establish a reputation for quality above the average. That efforts of this kind are worth while is well known. The establishment and maintenance of grades of wheat in Canada, of raw tobacco in the United States and of butter in Denmark have brought large sums of money to the farmers of these countries.

When the village community grows a single improved variety and when the individual growers all store their own seed, the time will have come for laying the coping stone on the co-operative movement. Co-operative marketing on a large scale will then be possible. The small grower must always be at a disadvantage in disposing of his produce. When, however, the village and the locality adopt co-operative sale the position will be reversed. When the volume of produce of the new types is considerable, merchants will always be found to compete for a large consignment. It will also be possible to ensure that the produce is properly weighed and that an account sales in writing is drawn up. Such methods are for the future but the time is rapidly coming when bulk transactions of this kind will be the rule in India. A few very promising experiments in the direction indicated have already been made by the Co-operative and Agricultural Departments for the sale of cotton. In Guntur in Madras, the co-operative sale of cured tobacco by the cultivators themselves is beginning.

Communications. Although a great deal of attention is being paid to railway development in India, the country in recent years has gone backwards as regards roads and their maintenance. A very noticeable falling off in this most important matter has taken place on account of the period of financial stringency through which India has just passed. Now that this phase has come to an end it is hoped that funds will be devoted to bring the main roads of the country into their former condition and also to provide the rural areas with

something better than the existing cart tracks. If designed with care so that new areas are opened up, it is extraordinary how a new road produces traffic and how the neighbouring markets benefit. A metalled road saves an enormous amount of cattle power and enables the cultivators to make much more use of their transport. Steps are being taken to improve the main roads of the country. On 3rd November 1927, the Government of India appointed a Committee of both Chambers of the Indian Legislature to consider (1) the development of the road systems of India and (2) the formation of a Central Road Board. This Committee has already dealt with a large volume of evidence. The final report was published in November 1928.

A good deal can be done to reduce the cost of maintenance of the road systems of India. Much unnecessary damage is now being done by the narrow wheels usually fitted to the bullock cart. If these could be replaced by stronger wheels with broad iron tyres, the roads would last longer and break-downs would be far fewer than is now the rule. The time is rapidly coming for the mass-production and sale of improved cart wheels in India. In this connection it would be interesting if accurate records could be made of the loss of man and cattle power, due to the collapse of cart wheels on the main roads which serve large cotton markets like Cawnpore or Indore. It must run into thousands of rupees annually.

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CHAPTER VII

A DEVELOPMENT BOARD OF RURAL RE-CONSTRUCTION

In the preceding chapters, frequent references have been made to the future development of rural India. It now remains to summarize the chief conclusions reached. One main idea has been steadily kept in view—the supreme importance of dealing with the Indian village and its fields as a single subject. During the last twenty years we have been passing through a period of experiment, in which rural problems have been approached independently from many points of view. Some of these undertakings have yielded valuable results; others have not been so successful. All have one characteristic in common. They have dealt with some particular aspect only of a much larger question. Further, there has been little or no co-ordination between the various agencies at work. The subject of rural re-construction is entering on a new phase. A re-grouping of the means is necessary for dealing with the new conditions. The present fragmentation of effort will no longer meet the case.

The work of the experiment stations during the last twenty years has established the fact that agricultural India is a vast undeveloped estate. By the adoption of simple improvements, which are well within the means of the average cultivator, crop-production can at least be doubled. Progress is also possible in animal husbandry provided the fodder supply can be increased.

As regards the best agency for devising improvements nothing has been discovered which can supplant the modern experiment station (provided with suitable laboratories), in which the investigator takes up a piece of land, copies the methods of the cultivator first of all and then with the aid of science devises

improvements in agriculture and evolves improved varieties of crops. In this work the attack must not be made on too narrow a front. As many sciences as possible must be combined and the larger problems must be approached simultaneously from several aspects. The importance of research work of this kind cannot be over-emphasized. It is the basis of the whole super-structure. If research is starved, the flow of improvements and of fertile ideas will cease. The country will then be left with expensive organizations doing nothing in particular.

The results obtained at the experiment stations are brought to the notice of the cultivators by an agency working in the Districts. The response of the cultivator to these efforts has not been so promising as the results yielded by the soil. The human factor is the one which stands in the way of progress. For rural development to proceed much further, it will be necessary to educate both the adult and the child. In both these matters, American experience seems to hold out the greatest hope of success. If India is to follow the lead of the southern states, a much greater concentration of effort will be needed and a number of independent movements—the extension work of the Agricultural and Veterinary Departments, the Co-operative Credit Movement and that portion of the work of the Educational Department which deals with primary rural schools—must at once be combined into a single agency. This might be designated the Development Board of Rural Reconstruction. At first the new body would establish the closest possible liaison with all the other organizations which deal with the country-side, namely, those concerned with the distribution of irrigation water and with roads, markets and rural sanitation. How rapidly these agencies will have to be absorbed is a matter for the future.

After a suitable organization for dealing with rural development as a whole has been established, the character of its personnel is of supreme importance. If the cultivator is to be made a willing partner in the new scheme he will have to be handled from the outset by men who are

in sympathy with him, who understand his point of view, who speak his language, wear his dress, and who can live in his village. One of the greatest difficulties will be to find and train an adequate supply of raw material for dealing with the people. The average town dweller, although possessing the education and knowledge necessary, is regarded almost as a stranger by the average cultivator. The intelligent village boy is often illiterate. The ideal agents for future work in the country-side will have to be trained.

After the nature of the agency has been settled and the personnel has been prepared careful working plans will have to be devised. For this purpose a survey of each province will have to be made, district by district. These will have to be discussed and definite projects adopted. These working plans will have to deal not only with what is possible now but also with what can be accomplished in the future.

Questions of finance and control remain. It is usual in official matters to finance everything by means of an annual budget largely for the reason that the income of the State is collected and recorded every year. When there is an annual surplus it is devoted either to the remission of taxation or to some matter of topical interest. The weaknesses of this system for dealing with problems like rural uplift are many and obvious. There is no reserve fund for lean years as is invariably the rule in all substantial business enterprises. Under the present system, a well considered programme, extending over, say, twenty years, which provides automatically for steady growth and for unforeseen developments, is impossible. Even the surpluses which occasionally occur are not always devoted to the same object. What is required is a special Fund for Rural Re-construction into which both annual contributions and surpluses can be paid. Such a measure would ensure continuity of effort, would establish confidence and would do much to attract and retain the necessary ability for dealing with the development of the country-side.

The various agencies which deal with rural India are at present controlled by the State and their activities form

a part of an official programme. They are therefore very prone to become involved in party politics, a region to which they do not properly belong. The development of rural India is not the sole concern of the Executive, of the Legislature, of any party or of any interest. It is a national matter and one in which the active co-operation of all well-wishers of India can be secured. It would be a great advantage therefore to remove this matter from official to un-official control. In each province, a Development Board should be created on which the Legislature, the Executive, the local notables and the most able of the workers could be represented. This board would in some respects resemble the present Indian Central Cotton Committee, a body which meets twice a year for dealing with all questions relating to the production, trade and utilization of cotton. If judiciously selected in the first instance and if care is taken to renew its youth in the future by the inclusion of the best men in the public life of the province, such a body would not only maintain direction but would also provide that driving power which is essential for real and steady progress. The most capable of the children of the soil would by this means be provided with opportunities for real constructive work. Simultaneously, with the spread of education, an electorate for the rural areas will be created.

APPENDIX

A SHORT DIRECTORY OF THE OFFICIAL AGRICULTURAL DEPARTMENTS OF BRITISH INDIA

I. Imperial Department of Agriculture

Agricultural Adviser to the Government of India and Director of the Agricultural Research Institute, Pusa—Head-quarters at Pusa, Bihar.

Agricultural Research Institute, Pusa—The following research officers are attached to the Institute: the Imperial Agricultural Chemist, the Plant Biological Chemist, the Physical Chemist, the Imperial Economic Botanist, the Imperial Mycologist, the Imperial Entomologist, the Second Entomologist (Dipterist), the Imperial Agriculturist, the Imperial Agricultural Bacteriologist, and the Secretary, Sugar Bureau. There is a farm of 830 acres attached to the Institute which trains post-graduate students in methods of research in various sciences allied to agriculture. The results of research work are published in the form of scientific memoirs and bulletins. The Institute also publishes *The Agricultural Journal of India* and *The Journal of the Central Bureau for Animal Husbandry and Dairying in India.*

Imperial Institute of Veterinary Research—Head-quarters at Muktesar with a sub-station at Izatnagar (Bareilly). The following officers are attached to the Institute : the Director, the Pathologist and three Veterinary Research Officers.

Imperial Institute of Animal Husbandry and Dairying, Bangalore—The following officers are attached to the Institute: the Imperial Dairy Expert, the Assistant Imperial Dairy Expert and the Physiological Chemist. The Institute has a farm of 250 acres with a sub-station at

Wellington (69 acres), a cattle-breeding farm at Karnal (2,154 acres) and a creamery at Anand. Advanced instruction is provided in animal nutrition, animal husbandry and dairying and pupils are trained for the Indian Dairy Diploma.

Imperial Sugar-cane Breeding Station, Coimbatore—The Government Sugar-cane Expert and the Second Cane-breeding Officer are attached to this station which is provided with a farm of 90 acres.

II. Provincial Departments of Agriculture

Assam

Director of Agriculture—Head-quarters at Shillong.

Economic Botanist—Head-quarters at Jorhat.

Deputy Director of Agriculture—Head-quarters at Jorhat (sugar-cane), 59 acres with the sub-stations of Upper Shillong (potatoes), 367 acres; Titabor (rice), 120 acres; Karimganj (rice), 80 acres; Khanapara, Gauhati (cattle), 200 acres.

Live Stock Expert—Head-quarters at Upper Shillong.

Bengal

Director of Agriculture—Head-quarters at Dacca (P. O. Tejgaon). The following research officers have their head-quarters at Dacca: the Agricultural Chemist (in charge of the Rangpur tobacco farm, 52 acres), the First Economic Botanist, the Second Economic Botanist, the Fibre Expert (in charge of the Rangamati farm, 17 acres), the Live Stock Expert (in charge of the Rangpur cattle farm, 333 acres) and the Agricultural Engineer.

Deputy Director of Agriculture, Eastern Circle—Head-quarters at Dacca, 657 acres with the following sub-stations: Kishoregunj (Mymensingh), 83 acres; Mymensingh, 20 acres; Faridpur, 20 acres; Comilla, 20 acres; Jamalpur (Mymensingh), 27 acres; Dhanbari (Mymensingh), 7 acres.

Deputy Director of Agriculture, Northern Circle—Alamnagar P. O., Rangpur—in charge of the stations of Rajshahi, 63 acres; Rangpur (demonstration), 19 acres;

Bogra, 29 acres; Pabna, 19 acres; Dinajpur, 24 acres; Mainaguri, 25 acres; Malda, 16 acres.

Deputy Director of Agriculture, Western Circle—Head-quarters at Writers' Buildings, Calcutta, in charge of the stations of Chinsura, 210 acres; Burdwan, 33 acres; Jessore, 5 acres; Gosaba, 8 acres; Berhampur, 44 acres; Bankura, 29 acres; Suri, 33 acres; Krishnagar, 35 acres.

Superintendent of Agriculture, Darjeeling District—Head-quarters at Kalimpong, 26 acres.

Deputy Director of Sericulture—In charge of the sericultural nurseries at Kalimpong, Kurseong, Berhampore, Tollygunge (Calcutta), Piasbari (Malda), Amriti (Malda), Kalitha (Birbhum), Mirganj (Rajshahi), Kumarpur (Murshidabad), Bogra, Bolpur (Birbhum), Dacca, Dhanbari and Vishnupur.

BIHAR AND ORISSA

Director of Agriculture—Head-quarters at Sabour. The following research officers have their head-quarters at Sabour—The Agricultural Chemist, the Economic Botanist and the Agricultural Engineer. An Assistant Director of Agriculture is in charge of the Sabour farm, 190 acres.

Deputy Director of Agriculture, North Bihar Range—Head-quarters at Sepaya (cattle breeding and sugar-cane), 379 acres with the following sub-stations—Siwan, 20 acres; Darbhanga, 26 acres; Purnea, 60 acres. Purnea is the head-quarters of the Assistant Director of Agriculture. The farm is the property of the Purnea Tournament Trust Fund.

Assistant Director of Agriculture, South-East Bihar Range—Head-quarters at Monghyr (dairy), 200 acres with the following sub-stations: Jamui, 38 acres; Banka, 26 acres.

Deputy Director of Agriculture, South Bihar Range—Head-quarters at Gaya, 193 acres with the following sub-stations: Nawada, 83 acres; Siris, 35 acres; Bikramganj, 24 acres.

Deputy Director of Agriculture, Chota Nagpur Range—Head-quarters at Kanke (Ranchi), 340 acres (in-

cluding dairy farm) with the following sub-stations: Netarhat (potatoes), 193 acres; Purulia, 52 acres; Ramgarh, 43 acres; Chianki, 32 acres; Sambalpur, 32 acres; Chaibassa, 38 acres.

Assistant Director of Agriculture, Orissa Range—Head-quarters at Cuttack, 150 acres with the following sub-stations: Khurda, 31 acres; Balasore, 75 acres; Angul, 47 acres; Puri (coconut), 42 acres; Anantapur, 30 acres (of which 26·2 acres were presented by the Hon'ble the Maharaja of Burdwan).

BOMBAY

Director of Agriculture—Head-quarters at Poona.

Agricultural College and Research Staff, Poona—In addition to the teaching staff and the Inspector in charge of Agricultural Schools, the following research officers have their head-quarters at Poona: the Agricultural Chemist, the Economic Botanist, the Crop Botanist (also in charge of the rice station at Karjat, 7 acres), the Plant Pathologist, the Horticulturist (also in charge of Ganeshkind, 80 acres; Modi Bag, 11 acres), the Agricultural Engineer, the Live Stock Expert (also in charge of two out-stations: Charodi, 2,251 acres and Bankapur, 285 acres). There are about 200 students in residence at the Agricultural College which teaches up to the B. Ag. degree of the Bombay University. Two farms are attached to the College: Poona, 289 acres; Kirkee (dairy), 362 acres. The Soil Physicist has his head-quarters at Manjri farm near Poona.

Deputy Director of Agriculture, Gujerat—Head-quarters at Surat, 292 acres with following sub-stations: Amalsad, 19 acres; Nadiad (tobacco), 44 acres; Broach, 6 acres; Dohad, 68 acres; Viramgam, 6 acres.

Deputy Director of Agriculture, North-Central Division—Head-quarters at Nasik with the following stations: Jalgaon, 204 acres; Dhulia, 28 acres; Sangvi, 48 acres.

Deputy Director of Agriculture, South-Central Division—Head-quarters at Poona with the following stations: Kopargaon, 110 acres; Mohol, 55 acres; Manjri

(sugar-cane), 62 acres; Baramati (sugar-cane), 21 acres.

Deputy Director of Agriculture, Southern Division—Head-quarters at Dharwar, 134 acres; with the following sub-stations: Tegur, 370 acres; Gokak Canal, 62 acres; Mugad, 9 acres.

Deputy Director of Agriculture, Konkan—Head-quarters at Ratnagiri, 93 acres, with the following sub-stations: Kumta, 22 acres; Karjat (rice), 9 acres.

Deputy Director of Agriculture, Sind—Head-quarters at Karachi with the following stations: Mirpurkhas, 270 acres; Jacobabad, 300 acres; Larkhana, 65 acres; Sukkur, 30 acres; Willingdon cattle-breeding farm, Karachi, 851 acres.

Burma

Director of Agriculture—Head-quarters at Rangoon.

Agricultural College and Research Institute, Mandalay—In addition to the teaching staff, the following research-officers have their head-quarters at Mandalay: the Agricultural Chemist, the Economic Botanist, the Entomologist, the Mycologist and the Agricultural Engineer. There are about 40 students in residence at the College which grants its own diploma. A farm of 630 acres is attached to the College.

Deputy Director of Agriculture, Northern Circle—Head-quarters at Mandalay with stations at Kanbalu, 534 acres; Padu, 105 acres; Chiba, 84 acres; Singaing, 102 acres.

Deputy Director of Agriculture, Myingyan Circle.—Head-quarters at Meiktila with the stations at Mahlaing, 254 acres; Kyehmon, 305 acres.

Deputy Director of Agriculture, West-Central Circle—Head-quarters at Thayetmyo with stations at Allanmyo, 144 acres; Pwinbyu, 22 acres; Sagaing, 11 acres; Magwe, 205 acres.

Deputy Director of Agriculture, East-Central Circle—Head-quarters at Pyinmana, 55 acres, with sub-stations at Tatkon, 106 acres; Yawnghwe, 37 acres; Pyu, 146 acres.

Deputy Director of Agriculture, Southern Circle—Head-quarters at Rangoon with stations at Hmawbi, 456 acres; Nyaunglebin, 15 acres; Pegu, 146 acres; Paungde, 126 acres.

Deputy Director of Agriculture, Arakan Circle—Head-quarters at Akyab, 138 acres with the sub-station of Kyaukpyu, 23 acres.

Deputy Director of Agriculture, Irrawaddy Circle—Head-quarters at Myaungmya, 92 acres with stations at Maubin, 155 acres; Henzada, 184 acres.

Deputy Director of Agriculture, Tenasserim Circle—Head-quarters at Moulmein with stations at Mudon, 88 acres; Thaton, 151 acres.

CENTRAL PROVINCES

Director of Agriculture—Head-quarters at Nagpur.

Agricultural College and Research Institute, Nagpur—In addition to the teaching staff, the following research officers have their head-quarters at Nagpur: the Agricultural Chemist, the Economic Botanist (also in charge of the Cotton research farm at Akola, 271 acres), the Second Economic Botanist, the Mycologist and the Agricultural Engineer. There are about 110 students in residence at the college which teaches up to the standard of the B. Ag. of Nagpur University. There is a farm of 268 acres attached to the College.

Deputy Director of Agriculture, Western Circle—Head-quarters at Amraoti with the following stations: Borgaon, 368 acres; Yeotmal, 106 acres; Khandwa, 177 acres; Basim, 110 acres; Buldana, 142 acres.

Deputy Director of Agriculture, Southern Circle—Head-quarters at Nagpur with the stations of Sindewahi, 197 acres; Tharsa, 116 acres; Wara-Seoni, 63 acres.

Deputy Director of Agriculture, Eastern Circle—Head-quarters at Raipur, 229 acres, with sub-stations at Chandkuri, 333 acres; Bilaspur, 253 acres; Drug, 281 acres.

Deputy Director of Agriculture, Northern Circle—Head-quarters at Jubbulpore, with the following stations: Adhartal (Jubbulpore), 637 acres; Saugor, 161 acres;

Damoh, 152 acres; Powarkhera (Hoshangabad), 528 acres; Narsinghpur, 130 acres.

Deputy Director of Agriculture in charge of Animal Husbandry—Head-quarters at Nagpur with the stations of Telinkheri (dairy), 1000 acres; Raigarh (cattle breeding), 1200 acres; Ellichpur, 268 acres; Bod, 160 acres; Pendra, 2000 acres.

Assistant Director of Agriculture, Plateau Sub-Circle—Head-quarters at Chhindwara, 69 acres with sub-stations at Seoni, 164 acres; Betul, 161 acres.

MADRAS

Director of Agriculture—Head-quarters at Madras.

Agricultural College and *Research Institute, Coimbatore*—The following officers engaged in research have their head-quarters at Coimbatore; the Agricultural Chemist, the Systematic Botanist, the Mycologist, the Entomologist, the Cotton Specialist, the Paddy Specialist, the Millets Specialist and the Research Engineer. There are from 100 to 120 students in residence at the Agricultural College which teaches up to the B. Sc. degree of Madras University. A farm of 478 acres is attached to the College.

Deputy Director of Agriculture, I Circle—Head-quarters at Vizagapatam with the following stations: Samalkota, 57 acres; Anakapalle, 36 acres.

Deputy Director of Agriculture, II Circle—Head-quarters at Guntur, 150 acres with a station at Marutur (paddy breeding), 50 acres.

Deputy Director of Agriculture, III Circle—Head-quarters at Bellary with the following stations: Hagari, 225 acres; Nandyal, 88 acres,

Deputy Director of Agriculture, IV Circle—Head-quarters at St. Thomas' Mount with the stations of Palur, 53 acres; Palakuppam (ground-nuts), 16 acres.

Deputy Director of Agriculture, V Circle—Head-quarters at Trichinopoly with a paddy breeding station at Aduturai, 53 acres.

Deputy Director of Agriculture, VI Circle—Head-

quarters at Madura with a cotton-breeding station at Koilpatti, 82 acres.

Deputy Director of Agriculture, VII Circle—Head-quarters at Tellicherry with stations at Kasaragod (coconuts), 126 acres; Taliparamba, 86 acres; Pattambi (paddy breeding), 82 acres.

Deputy Director of Agriculture, VIII Circle—Head-quarters at Coimbatore with a betel vine station at Vellalur, 2 acres.

Deputy Director of Agriculture, Live Stock—Head-quarters at Hosur, 1,635 acres with sub-stations at Chintaladevi, 767 acres; Guntur (buffaloes), 150 acres.

Curator with head-quarters at Ootacamund with a sub-station at Nanganad (potatoes), 36 acres. There is also a pomological station at Coonoor, 12 acres.

North-west Frontier Province

Agricultural Officer—Head-quarters at Tarnab (Peshawar), 200 acres with a sub-station at Haripur, 20 acres.

Punjab

Director of Agriculture—Head-quarters at Lahore.

Agricultural College, Lyallpur—In addition to the teaching staff the following research officers have their head-quarters at Lyallpur: the Agricultural Chemist, the Second Agricultural Chemist, the Bacteriologist, the Associate Professor of Botany, the Fruit Specialist, the Second Fruit Specialist, the Millet Botanist, the Cerealist, the Entomologist, the Agricultural Engineer, the Second Agricultural Engineer, the Executive Engineer (Lift Irrigation), the Cotton Research Botanist and the Mycologist. There are about 244 students in residence at the College which teaches up to the M. Sc. (Agr.) of the Punjab University. There is a farm of 84 acres attached to the College. The Professor of Agriculture is in charge of the Lyallpur farm, 430 acres and of the Risalewala farm, 858 acres. The Associate Professor of Botany is in charge of the botanical farm and fruit garden, 115 acres.

There is also a Cotton Research farm at Risalewala, 220 acres.

Deputy Director of Agriculture, Gurdaspur—Head-quarters at Gurdaspur, 263 acres with sub-stations at Gujranwala, 100 acres; Sialkot, 50 acres; Kala Shah Kaku, 146 acres ; Beas, 43 acres ; Khalsa College farm, Amritsar, 50 acres. The Poultry Expert is stationed at Gurdaspur.

Deputy Director of Agriculture, Hansi—Head-quarters at Hansi, 589 acres with sub-stations at Sirsa, 419 acres; Rohtak, 100 acres; Gurgaon, 100 acres; Ambala, 99 acres; Ferozepore, 100 acres.

Deputy Director of Agriculture (Professor of Agriculture), Lyallpur—Head-quarters at Lyallpur, 430 acres (experimental) and 858 acres (seed) with a sub-station at Jhang, 200 acres.

Deputy Director of Agriculture, Multan—Head-quarters at Multan, 529 acres with sub-stations at Dera Ghazi Khan, 139 acres ; Mianwali, 207 acres.

Deputy Director of Agriculture, Montgomery—Head-quarters at Montgomery, 549 acres with sub-stations at Shergarh (seed) 261 acres; Ganji Bar, 558 acres; Raewind, 46 acres; Fitna, 500 acres.

Deputy Director of Agriculture, Rawalpindi—Head-quarters at Rawalpindi, 252 acres with sub-stations at Sargodha, 657 acres; Chillianwala, 250 acres; Cambellpur, 100 acres ; Gujrat, 50 acres.

Deputy Director of Agriculture, Jullundur—Head-quarters at Jullundur, 50 acres with sub-stations at Ludhiana, 54 acres ; Kangra, 10 acres.

UNITED PROVINCES

Director of Agriculture—Head-quarters at Shahjahanpur.

Agricultural College and Research Institute, Cawnpore—In addition to the teaching staff the following research officers have their head-quarters at Cawnpore: the Agricultural Chemist, the Economic Botanist, the Assistant Economic Botanist (in charge of the Cotton

research farm at Raya, Muttra), the Second Economic Botanist, the Entomologist, the Plant Pathologist, the Agricultural Engineer, the Second Agricultural Engineer and the Third Agricultural Engineer. There are about 180 students in residence at the College which grants its own diploma of L. Ag. A large farm and a model dairy are attached to the College.

Deputy Director of Agriculture, Central Circle—Head-quarters at Cawnpore, 71 acres with sub-stations at Kalianpur (near Cawnpore), 263 acres; Etawah, 61 acres; Hardoi, 55 acres; Mainpuri, 53 acres.

Deputy Director of Agriculture, Eastern Circle—Head-quarters at Partabgarh, 90 acres with sub-stations at Naugawan (Sultanpur), 400 acres; Fyzabad, 206 acres; Benares, 78 acres; Rae Bareilly, 12 acres.

Deputy Director of Agriculture, Western Circle—Head-quarters at Aligarh, 88 acres with sub-stations at Kalai (Aligarh), 142 acres; Muzaffarnagar, 100 acres; Agra, 100 acres; Muttra, 36 acres; Bulandshahr, 25 acres.

Deputy Director of Agriculture, North-Eastern Circle, Gorakhpur—Head-quarters at Gorakhpur, 110 acres with a sub-station at Bahraich, 102 acres.

Deputy Director of Agriculture, Rohilkhand Circle—Head-quarters at Shahjahanpur, 163 acres with sub-stations at Nawabganj (Bareilly), 119 acres; Nagina (Bijnor), 77 acres.

Deputy Director of Agriculture, Bundelkhand Circle—Head-quarters at Jhansi with sub-stations at Attarra (Banda), 171 acres; Jaitpur (Hamirpur), 30 acres.

Deputy Director of Agriculture, Hill Circle—Head-quarters at Jeolikote (Naini Tal), 51 acres.

Deputy Director of Agriculture in charge of cattle-breeding operations—Head-quarters at Madhurikund farm (Muttra), 613 acres with a sub-station at Manjhara (Kheri), 553 acres.

Agricultural Schools—The Bulandshahr agricultural school has accommodation for 100 students and is being extended to accommodate 140. Four courses are given: (1) a two years' agricultural course; (2) a farm mechanics course (6 months); (3) a course for fieldmen (6 months); (4) a training course for agricultural teachers in middle

schools (1 year). The school is provided with a farm of 45 acres, laboratories, workshops, a dairy and small power machinery. The staff consists of a Principal and Lecturers in agricultural science and engineering. A second agricultural school is being established in Gorakhpur on similar lines and will be completed in 1930.

Deputy Director in charge of Government Gardens—Head-quarters at Saharanpur. Government gardens are maintained at Agra, Allahabad, Almora, Lucknow and Saharanpur.

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